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Vol, XXI, Part I

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Original articles

ORIGINAL ARTICLES

THE NOMENCLATURE AND DISTINCTIVE CHARACTERS OF SOME CITRUS ROOTSTOCKS TRIED IN THE PUNJAB

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(Received for publication on 29 May 1950)

(With Plates I—VIII)

THE vernacular names of the citrus rootstocks under trial in the Punjab along with their possible English equivalents were mentioned in a previous communication by Lal Singh and Sham Singh [1942]. Since then, a great volume of information about the influence of these rootstocks on some commonly grown citrus fruits like malta, *sangtra* and grape fruit in respect of tree vigour, productivity, fruit quality, etc. has accumulated, some of which has already been published [Lal Singh and Sham Singh, 1942, 1944 and Sham Singh and Nagpal R. L., 1947]. The rootstock influences being distinctly different in respect of tree performance, it is necessary that the characteristics of rootstocks themselves be given out in greater detail partly to help elucidating the so-called ' stock influences ' and partly to straighten the prevalent nomenclature about them. In view of these considerations, attempt has been made in the present communication to give as complete an account of these rootstocks as possible to dispel much of the confusion prevalent about the nomenclature of indigenous rootstocks not only in the minds of the horticulturists abroad, but also in case of the horticulturists and the fruit growers in this country.

It is a well-known fact that citrus rootstocks are known under different names in different parts of the country which is obviously due to the diversity of languages spoken therein. Thus a particular species may be known under several apparently distinct names in various provinces and sometimes even in different parts of the same province, which indeed is bad enough but the confusion gets worse confounded when distinctly different species are assigned one and the same name in different localities. The names assigned to a certain species in a given province can sometimes be so arbitrary and widely different that it becomes almost impossible to convey the correct information to an average grower who is usually guided by the commonly spoken vernacular names. In fact, several vernacular names are frequently used interchangeably and the effect of one rootstock is often misconstrued for the influence of another. The confusion may be well illustrated by the work of Brown [1920]. This work has been widely quoted in many standard books on horticulture (*Fundamentals of Fruit Production* by Gardner, Bradford and Hooker, p. 638 and *Citrus Industry*, Vol. II by Batchelor and Webber, p. 81). A critical examination of the material of Brown's work shows that the rough lemon employed by him was actually

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something entirely different and has been usually referred to as *kharna khatta* (*C. karna*) which may be a chance hybrid between sour orange and rough lemon. The standardisation of vernacular names for different species is, therefore, as important as their equivalents in English or the specific names. Accordingly, an effort has been made in this paper not only to straighten out the nomenclature that has caused a widespread confusion, but also to include descriptive notes on some well-known species with a view to fit in the various forms according to the most widely accepted classification. The coloured and photographic representations depicting detailed features of fruits, flowers and leaves are also given along with descriptive notes. These Plates form a special feature of this paper and are considered essential to clarify the various issues concerning citrus rootstocks. The reader is thus greatly facilitated to diagnose or distinguish such forms, the vernacular names of which have not found a place here for one reason or another.

Material used

The citrus rootstock experiments were initiated in the Punjab in 1932, when all possible species and varieties of citrus, used as rootstocks, were obtained from various citrus growing parts of India and Ceylon. Seeds and cuttings of these varieties were, as far as possible, obtained from the same parent tree in each case. In all, forty strains from seeds were raised successfully out of which twentysix could also be propagated by vegetative means. This material was transplanted in the orchard in February, 1934 with a view to :

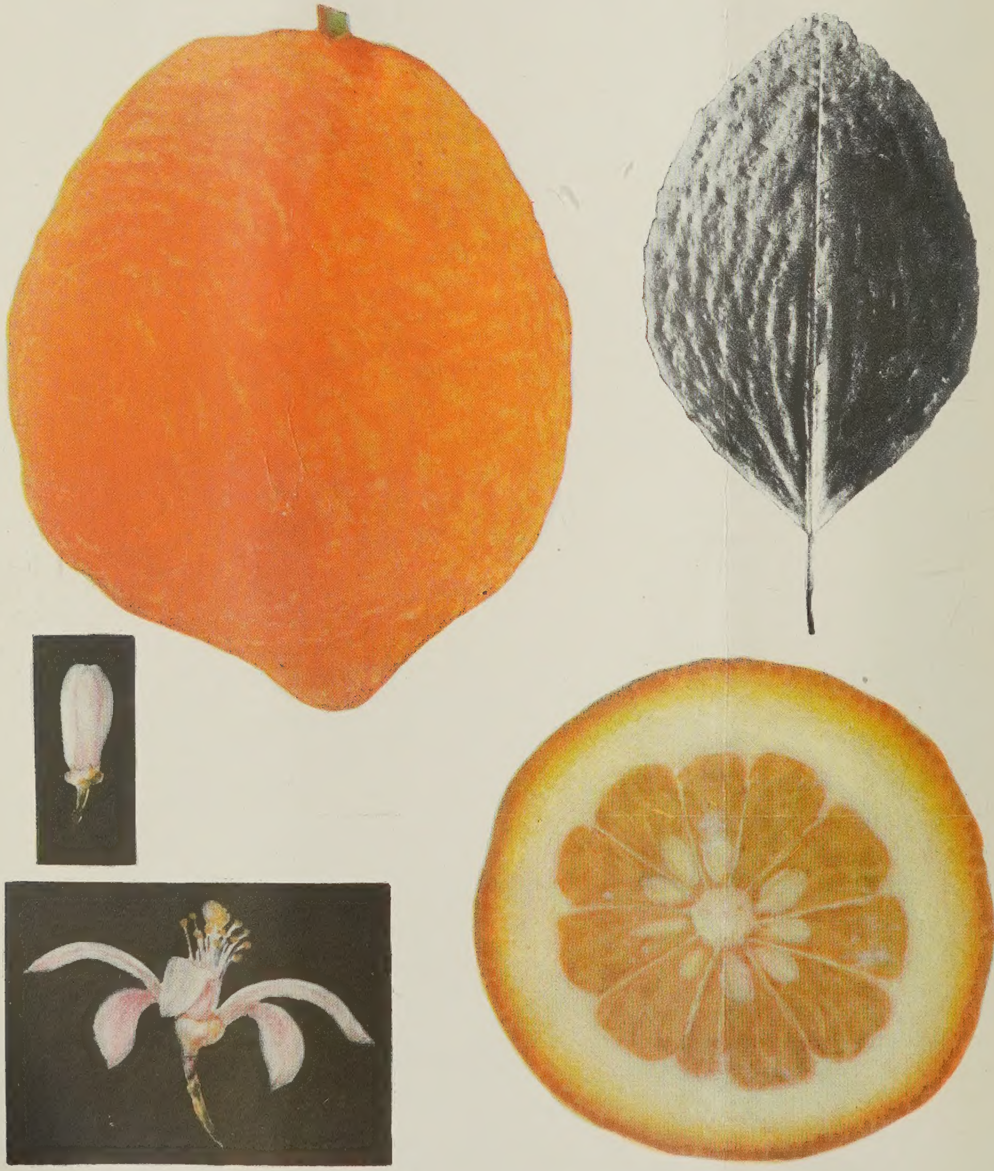
(*a*) to compare the performance of progeny plants produced from a particular variety by (i) hard wood cuttings and (ii) apogamic seedlings,

(*b*) to straighten the existing confusion about the nomenclature of varieties through a detailed study of their morphological and other characters.

It is this material which formed the subject of studies reported in this paper. When the material (fruits and cuttings) was received, it was evident that in many cases the varieties under different names looked almost alike. No attempt was made to isolate them by studying the fruit characteristics alone, but the local names under which they were received were preserved to form an idea, in due course of time, to prepare a list of synonyms for each distinct species or variety. Such names are given along with the botanical descriptions of the various varieties.

Descriptions recorded

Varieties received under distinct names were separately described for all characters. Even the same variety propagated by the two methods, namely cuttings and seed, was also separately described. In cases where varieties were found identical in all the characters, grouping was done and the names of varieties forming one group were recorded as synonyms, the most popular name being assigned to the group as a whole. The trees of the same variety propagated by the seeds and cuttings differed only in respect of tree shape while all other characters remained unchanged. The trees raised from seeds were found to be comparatively more



KHARNA KHATTA

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tall and upright irrespective of variety or species, whereas their contemporaries raised from cuttings were always more spreading.

In recording leaf measurements ten normal leaves from the middle of the current year's shoot were taken and the flower parts were counted by taking ten hermaphrodite flowers in each case.

Grouping of varieties, their synonyms and descriptive characters :

(1) *Kharna khatta* (Plate I)

Synonyms :

Id. lemon	(Poona, Bombay)
Soh sarakar	(Assam)
Mokari	(Renala Khurd, Punjab)
Kharna khatta	(Punjab)
Kharna lime	(Uttar Pradesh)

This species appears to be unknown in the West and it has no English equivalent excepting the general term rough lemon, which, as will be seen later, is the correct term for *jattikhatti*.

This is used as a rootstock more commonly in the Uttar Pradesh than in other parts of the country. It is known in that province by the name of *kharna lime* and, in the Punjab, where it came to be naturalized as *kharna khatta*, this species entered as stock portion of thousands of budded citrus trees supplied by Agra nurserymen to prospective growers in canal colonies in the first quarter of the present century. It is also met within the Kangra District of Punjab in both cultivated and wild forms and is known there by the name *turanj*. Its cultivation in the Kangra Hills suggests that the species is also a native of the Punjab but the local name remained confined to that part of the province and did not gain ground due to difficult communication with other parts. The name *mokari* with which this species is also erroneously associated in the Punjab is a misnomer and requires to be given up entirely.

It is probable that this species may have some other distinct names in certain other parts of the country like those prevalent in Bombay, Assam, Uttar Pradesh and the Punjab. The growers in those tracts would do well to compare the characteristics of such allied yet differently named forms with those mentioned here in order to identify them properly. It appears feasible that *kharna* or better still *kharna khatta*, with which its scientific name *C. karna*, Raf. is associated, be adopted as a country-wide vernacular name for this species to distinguish it from others. *C. karna* Raf. [1838] referred to by Batchelor and Webber (*Citrus Industry*, Vol. I h. 402) as *Citrus aurantium* is actually this fruit. It would appear that these workers consider *C. karna* and *C. aurantium* as synonymous which does not appear to be correct. According to them (*Citrus Industry*, Vol. I, p. 488) Bonavia assumed this fruit to be sour orange (Bonavia, *The cultivation of oranges and lemons of India*

and Ceylon. Allen & Co., Limited p. 10 and 251), whereas Gandhi (*Cultivation of Citrus Fruits in India*—Calif. *Citrograph* 19, p. 345) considers this fruit to be closely related to rough lemon. The description of this variety given below shows that the characters do not resemble any of these but are midway between those of rough lemon and sour orange and it is probable that this may be a chance hybrid between the two.

Description. In view of the fact that this species is often confused with or considered allied to rough lemon it is necessary to compare the characteristics mentioned below with rough lemon (*jatti khatti*).

Tree tall and spreading, invariably more vigorous than the rough lemon tree ; petiole long (average length 1·3 cm.) and thick, usually margined ; petiolar wings invariably better developed than in case of rough lemon ; leaf shape ovate or obovate (average length 7·77, breadth 5·58 and ratio 1·39). Invariably broader than rough lemon leaf ; margin usually serrate ; base and apex usually acute ; apex sometimes obtuse or emarginate ; size of flower buds and intensity of petal colour midway between rough lemon and citron ; (sepals 5 petals 5, stamens 27-34) fruit orange coloured, often m mmilate like citron ; rind very thick, spongy and sweetish ; pulp orange coloured, sour but with a flavour characteristic of orange rather than that of the lemon ; segments 9-13 ; centre solid ; average number of seeds per fruit 36.

(2) *Jatti khatti* (rough lemon) (Plate II)

Synonyms :

Khatti	(Uttar Pradesh)
Khatta	(Punjab)
Jatti khatti	(Punjab)
Khatti	(Punjab)

This species is widely used as a rootstock in many countries especially in South Africa, Australia and Florida in the U.S.A. In our own country its use is limited to the Uttar Pradesh, Madhya Pradesh and the Punjab. In fact, it was not received from any citrus growing tract in India, when, in 1932, all the important rootstock species were requisitioned from those tracts for trial in the Punjab.

The species is known in English as rough lemon and *jatti khatti* appears to be its correct vernacular translation. Hence *jatti khatti* is the term which should be popularized in preference to all other terms assigned to it.

Description. Tree tall and spreading ; petiole small and thin (average length 0·83 cm.) naked or margined ; leaf-shape ovate (average length 7·29, breadth 4·03 and ratio 1·83) ; margin usually crenate, both base and apex acute ; petal colour pink with a little less intensity than in case of *khanra khatta* : (sepals 5, petals 5-6 and stamens 24-30) ; ripe fruit colour midway between lemon yellow and orange ; fruit shape ovoid, usually ma-millate and somewhat chagrined ; rind medium thick ; pulp pale, acid abundant ; segments usually ten ; centre hollow ; average number of seeds 24.

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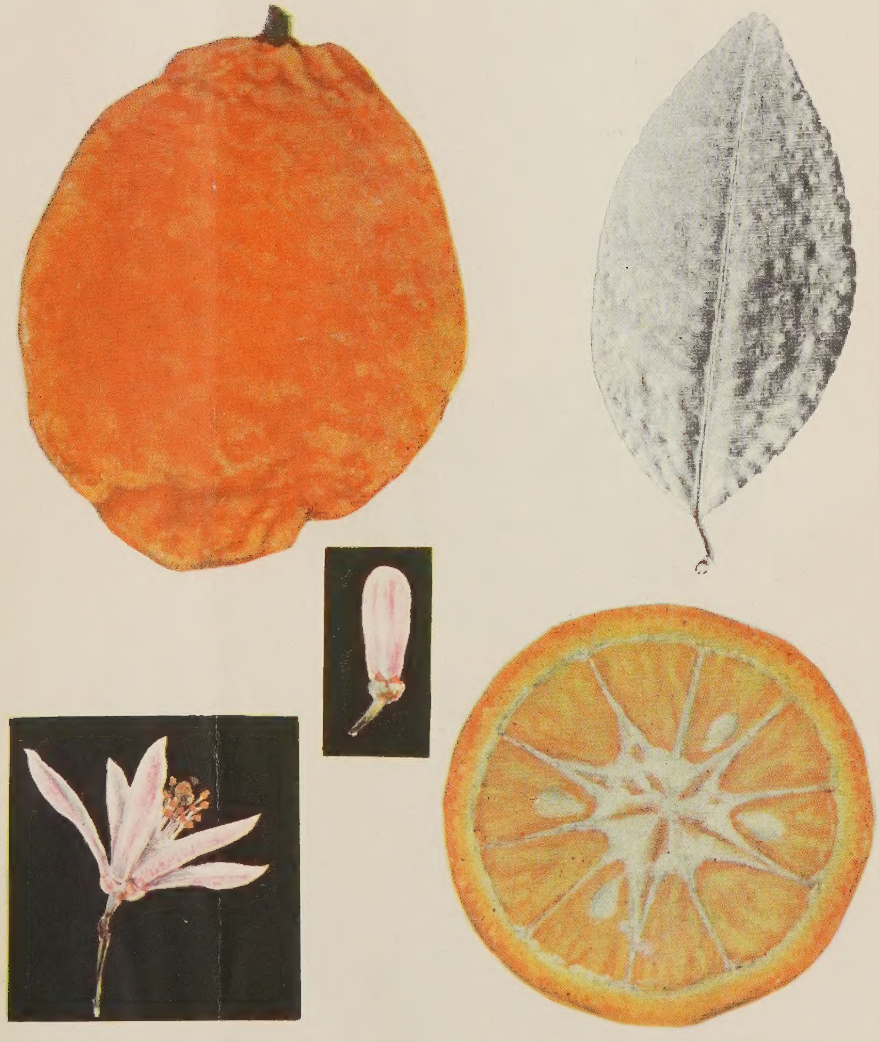

JATTI KHATTI

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JAM BERI

JULLUNDURI KHATTI

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(3) *Jamberi* (Plate III)

Synonyms :

Jamberi brown	(Uttar Pradesh)
Jamberi	(Madras)
Jamburi	(Bombay)

The *jamberi* is used widely as a rootstock in central, eastern and southern parts of India wherever citrus fruits are grown. It is a distinct species by itself, but in view of the term having been incorrectly translated as rough lemon, it is often referred to in literature either as true rough lemon or a form of it. There is of course, room for mistaking it for real rough lemon since the tree and leaf characters of the species very closely resemble those of rough lemon. The fruit, however, is markedly different in all characteristics and can be readily differentiated from rough lemon fruit by pressure of the hand even in early stages of development. On maturity, as the Plate III would show, there cannot be even the slightest room for confusing it with rough lemon. In view of the lemon yellow colour and loose character of rind, this species was rightly named by Lushington as 'lime loose jacket' or *jhambiri* orange. There could not be a better literal translation of *jhambiri* as given above, and it is suggested that these English equivalents should be adhered to in order to isolate it from rough lemon, with which it is so ferquently confused.

Description. Tree tall and spreading like rough lemon; petiole small and thin (average length 0·82 cm.) naked or margined; leaf shape ovate (average length 8·54, breadth 4·33 and ratio 1·97); margin usually crenate or serrate-crenate; both base and apex acute; petals pink; (sepals 5, petals 5-7 and stamens 26-32) ripe fruit lemon yellow, globose, with depressed mamilla at the apex and folds at the base (stalk end); rind thin and loose; pulp pale or lemon yellow; segments 9-12; centre hollow; average number of seeds 19.

(4) *Jullunduri khatti* (Plate IV)

So far as the author is aware, this species has not been recorded by previous writers on the subject. It seems to be unknown in most parts of India excepting the Punjab, where it is used as a rootstock for malta and *sangtra* to a limited extent. In early stages of development, the fruit of this species is also sold in mixed condition with *kaghazi nimboo* (sour lime), but so far as its quality for lime juice cordial or pickling is concerned, it is definitely far inferior to *kaghzi nimboos.* The mixed lot of fruit of both the species can, however, be sorted out without much difficulty if one gets acquainted with the furit characteristics of these species.

Jullunduri khatti is the only vernacular name for this species and that too is well-known all over the province. The species got this name probably due to the fact that it originated as a natural cross in the Jullundur District, from where it gradually migrated to other parts of the province. As the species comes true to type from seed and is distinctly different from others in all respects, it deserves a

suitable specific name. In the meanwhile, the term smooth lemon may be popularized as English translation of the term *Jullunduri khatti*.

Description. Tree tall but comparatively more spreading than that of rough lemon (*jatti khatti*) ; petiole small and thin (average length 0·76 cm.) ; naked or margined ; leaf ovate (average length 7·24, breadth 4·27, and ratio 0·76) ; margin serrate-crenate ; narrowed at base and apex ; petals pink ; size of flowers and flower buds smaller than in case of rough lemon ; (sepals 5-6, petals 4-7, stamens 24-34) ; rind thin and orange tinted : fruit smooth, small sized, spherical with a rudimentary and depressed mamilla at the apex ; pulp pale yellow but gets orange tinted on ripening ; segments 9-12 ; centre hollow ; average number of seeds 16.

(5) *Mokari* (*citron*) (*Plate V*)

Synonyms :

Turanj	(Renala Khurd, Punjab)
Nattran	(Ceylon)
Sohmad	(Assam)
Sak limboo	(Poona, Bombay)
C. mahalung	Poona, Bombay
Mokari	(Punjab)

The English equivalent of this species is citron. It is found to have two main forms : one where the rind is very rough, corrugated and orange on ripening (*C. mahalung*, Ponna) and other where the rind is smooth and is yellow on ripening (*mokari*, Punjab). It is the latter form, which is frequently used by nurserymen as a rootstock.

The tree of this species is usually dwarf and spreading. The back colour of the twings is yellow on ripening. The limbs often touch the ground due to heavy load of the fruit borne by them and the parts of the twigs touching the soil strike roots readily. The nurserymen, therefore, raise stock of this species by the rooting of cuttings, whereas with the exception of sweet lime, *jatti khatti*, *Jullunduri khatti* and *kharna khatta* which can be propagated vegetatively to a limited extent, the cuttings of most other species do not root well in the open. In view, therefore, of the case with which it can be grown from cuttings and the fact that the stock attains the budding stage comparatively much early this species finds special favour with nurserymen, whose chief aim has always been to produce budded trees in the shortest possible period.

The most commonly spoken name for this species all over the Punjab is *mokari* which should therefore be retained in preference to any other. A standard name for whole of the country also appears necessary.

Description. Tree dwarf and spreading ; petiole small and thick (average length 0·68 cm.), naked ; leaf oblong elliptic (average length 8·39, breadth 5·35 and ratio 1·27), acute at base but usually obtuse at apex, margin serrate ; young shoots

MOKARI

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KHATTA

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glabrous, purple ; flowers often unisexual, petals pink (sepals 5, petals 5, stamens 40-45) ; fruit ovoid or oblong, mamillate at the apex ; colour lemon-yellow ; rind very thick, white and of carroty consistence ; pulp pale yellow ; juice sour and scanty ; segments 10-14, usually 12 ; centre a bit hollow ; average No. of seeds 110.

(6) *Khatta* (Plate VI)

Synonyms :

Khatta	(Taru Jabba, Peshawar, N. W.-F. P.).
Kimb, khatta	(Punjab and Bombay)
Saville kimb	(Renala Khurd, Punjab)
Soh tang	(Assam)
Naradabba	(Madras)
Herale	(Mysore)

It is evident that there are only two vernacular names for this species viz. *khatta* and *kimb*, the former being more appropriate, requires to be popularized throughout the country. It appears that the species is not used as a rootstock anywhere in India but is cultivated largely as a hedge plant or as an ornamental tree.

There are several English equivalents for this species viz. sour florida, seville orange, bitter seville and sour orange but the last name is more appropriate and commonly used. It grows into a tall and erect tree. The foliage is dark green and makes a very effective protective hedge around bungalows. It has never been noticed to be attacked by citrus canker in the Punjab and it is likely that the species is resistant to this disease.

Germination percentage of seed is usually low. The seed is not fully ripe by the beginning of September in the Punjab, when most other species can be sown for the raising of nursery stock.

Description. Tree tall and erect ; petiole long and thick (average length 2·47 cm.) ; often broadly winged ; leaflet elliptic or ovate, acute or obtuse at base and acute or accuminate at the apex ; (average length 7·97, breadth 5·42, and ratio 1·49 cm. margin crenate ; flowers pure white, bisexual ; (sepals 5, petals 5, stamens 22-25) fruit globose, not mamilate but apex slightly depressed, orange coloured ; rind rather thick and often intensely bitter ; pulp pale orange, sour and somewhat bitter ; segments 8-12, usually 10 ; centre solid ; average No. of seeds 36.

(7) *Mitha* (sweet lime) (Plate VII)

Synonyms :

Sakhar nimbu	(Bombay and Nagpur)
Sharabati	(Peshawar, N. W. F. P.)
Mitha	(Punjab)
Shi nimbu	(Mysore)
Soh phai	(Assam)

This species has been found to have two main forms : one where the rind is thick and rough, the fruit is large and often develops orange tint on ripening and the other where the rind is smooth, very thin and is yellow on ripening. It is the latter form which has been described here. Its commonly spoken vernacular name is *mitha* in the Punjab. A standard name also requires to be decided for the country as a whole. Its correct English equivalent is sweet lime, although in some places it is also called sweet lemon, which term should be dropped in favour of sweet lime.

The seed content of sweet lime being very low, it is multiplied by the rooting of mature wood cuttings. When thus grown, the stock has the advantage of becoming fit for budding comparatively early. The fruit of this species is largely consumed in fresh condition firstly because the period of its availability (August to September) synchronizes with the malarial season and secondly because it is available at a time when no other citrus fruit can be found in the market. It is also prescribed by the Ayurvedic physicians to patients suffering from several ailments, especially against disorders of liver.

Description. Tree vigorous and spreading ; petiole fairly long and thick (average length 1·11 cm.) naked or margined ; leaf ovate, acute or obtuse (average length 8·77, breadth 5·38, and ratio 1·66) ; margin crenate ; flowers pure white. unisexual or bisexual (sepals 5, petals 5, stamens 25-36) ; fruit globose, yellow ; rind very thin and smooth ; pulp pale yellow ; juice abundant, sweet but not aromatic ; segments 8-12 usually to ; average number of seeds 5.

(8) *Nasnaran* (Plate VIII)

This species was introduced into the Punjab from Ceylon, in 1932, through the courtesy of the Curator, Royal, Botanic Gardens, Paradeniya. There could hardly be any dispute for its regional name as, apparently, it is not grown all over the country.

Description. A fairly tall and erect growing shrub ; petiole short and thin (average length 0·95 cm.) often winged ; leaflet elliptic or ovate, acute or obtuse at base but acute or acuminate at the apex (average length 3·9 cm., breadth 2·2 and ratio 1·76) ; margin crenate ; flowers very small and white with a pinkish shade, bisexual ; fruit small globbose with a prominent depression at the apex and folds at the base ; colour lemon yellow ; rind thin and loose ; pulp yellow ; segments usually ten ; centre hollow ; average number of seeds 13, greenish when cut.

MITHA

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NASNARAYAN

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REFERENCES

Batchelor, L. D. and Webber, H. J. (1946, 1948). *Citrus Industry* I and II, University of Calif, Press, Barkely

Brown, W. R. (1920). A series of stock trials in Peshawar. *Agric. Res. Institute, Pusa* Bull. 93

Bonavia, E. (1880). *Oranges and lemons of India and Ceylon.* W. H. Allen & Co.

Gardner, V. R. Bradford, F. C. and Hooker, H. D. Yeon (1939). *The fundamentals of Fruit Production.* Mc Graw Hill Book Company, Inc. New York

Lal Singh and Sham Singh, (1942). Citrus rootstock trials in the Punjab I. *Indian J. agric. Sci.* XII

Lal Singh and Sham Singh (1944). Citrus rootstock trials in the Punjab II. *Indian J. agric. Sci.* XIV

Sham Singh and Nagpal, R. L. (1947). Citrus rootstock trials in the Punjab III. *Indian J. agric. Sci.* XVII

DEVELOPMENT OF *DURUM* WHEATS IN MALWA

By K. M. Simlote, Institute of Plant Industry, Indore

(Received for publication on 14 March 1950)

(With four text-figures)

Hutchinson and Panse [1936] have reported the results of a large number of varietal trials on wheats (*T. durum* and *T. vulgare*) conducted by the Institute of Plant Industry in Central India and Rajputana States, during the period 1932-33 to 1934-35. The local bulks were generally found superior in yield to the imported strains from the neighbouring provinces. It was, therefore, evident that 'ready made' strains from outside the Central India States could not be introduced into this tract and the only course open for improving the local wheats was to resort to selection. With this object in view, hundreds of single plants were selected from the cultivators' fields of local wheat crop in the various member States. After multiplying the seeds of best of these for a couple of years, they were then tested in varietal trials along with the local bulk as a control. The new selections also did not give significantly higher yield of grain than the control. It was, therefore, inferred from these trials that yield of grain in wheat appears to be a complex character being the net result of the interaction of several factors on those characters which directly or indirectly contribute to yield. It should, therefore, be interesting to study the development of those characters which make up the yield, as such a study would enable the breeder to interpret yield differences between different varieties during the period of their growth in terms of certain characters which are responsible for high or low production of grain. Developmental studies of five ecological types of *durum* wheat and one *turgidum* type were therefore undertaken by the author as a part of wheat improvement programme at the Institute in 1941-42 and 1942-43 seasons.

Experimental material and the layout

The experiment originally consisted of six varieties of wheat—three from Central India, namely, Dhar selection, Rewa 42 and N-111, and three from outside, namely, Bansi 168 from Bombay, 137-7 from Madhya Pradesh and Hyd. 557-10 from Hyderabad. All the varieties belong to *T. durum* except N-111 which belongs to *T. turgidum* and therefore it was excluded from the analysis of results reported in this paper. The five varieties were grown in 1941-42 season in five randomised blocks, each plot consisting of three lines 14 in. apart and 20 feet long. In each line, seeds were dibbled 4 in. apart. After the germination was over, three foot lengths were selected at random in the central line of each plot in each block. Each foot length, therefore, had 3 plants. Observations on tiller development on plants of each of these three foot lengths were begun one month after sowing and continued every fortnight until the number of tillers was found to be constant. Observations on ear development were taken on the same plants as soon as the ear heads first

appeared and continued every week until maturity. After the sampling units were harvested, yield of grains per plant, number of grains per ear and weight of 100 grains were recorded for each plot and the data analysed statistically.

The experiment was repeated in 1942-43 season also.

Tiller development

The first observation on tiller development was taken during the two seasons after 30 days of sowing, that is, on 3 December, 1941 and 25 November, 1942 respectively.

Development of tillers had started even earlier than the first observation in both seasons, and within the first fifteen days, that is, after 45 days of sowing the rate of development was very high. In the second fortnight, that is, between 45 days and 60 days of sowing, though fresh tillers continued to develop, the rate of development had considerably slowed down and the plants reached their maximum at the third count, that is, after 60 days of sowing in both the seasons. After the maximum was reached, tillers started gradually dying off, and the number became constant after 105 and 120 days of sowing in 1941-42 and 1942-43 seasons respectively. Table I shows the progress of tillers development in the five varieties for both seasons. It will be seen in this table that though the mean number of tillers per plant at the initial count taken after 30 days of sowing was more or less the same in both seasons, the mean number of tillers subsequently produced per plant was higher in 1942-43 season than in 1941-42 season. This was probably due to the following causes :

(i) The 1942-43 season was better than 1941-42 season from an agriculturist point of view as the average yield of wheat per acre was higher in 1942-43 than in 1941-42 on account of better distribution of winter rains. The average yield per acre of local *durum* wheat of the institute fields was 4·8 maunds and 5·6 maunds in 1941-42 and 1942-43 seasons respectively (*vide* reports of the Institute of Plant Industry for 1941-42 and 1942-43). The months of October, November and December in 1941-42 season were dry except for a shower in the beginning of January, 1942, but in 1942-43 season, light showers were received in the months of December and January and which were favourable for the growth of wheat crop. (ii) The experiment in 1942-43 was carried out on a richer field and an additional watering was given one month after sowing in 1942-43 when plants were observed dying off, over and above an irrigation given to the plots just before sowing which was a common feature in both seasons.

The development of tillers at different counts (dates of observation) in each of the five varieties was statistically analysed and the analysis of variance for the two seasons is given in Table II. The experiment was laid out as a simple randomised block layout, but as tiller counts taken in the same plot on different dates are analogous to the sub-plots of a split plot design, the analysis has been done accordingly. The varieties are compared with error (*a*) and the dates of observation and interaction between dates and the varieties are compared with the sub-plot error (*b*).

TABLE I

Shows the progress of tiller development (mean per plant) in the five durum types

1941-42								1942-43								
Date of observation	Count	Dhar selection	Rewa-42	Hyderabad 557–10	Bansi 168	Madhya Pradesh 137-7	Mean per count	Date of observation	Count	Dhar selection	Rewa 42	Hyderabad 557–10	Bansi 168	Madhya Pradesh 137-7	Mean per count	Number of days after sowing
3 December 1941	I	3·38	3·05	2·19	2·36	2·67	2·73	25 November 1942	I	2·12	2·37	2·03	1·82	2·09	2·08	30
18 December 1941	II	6·53	5·39	3·40	3·18	4·08	4·51	10 December 1942	II	10·68	7·15	7·16	5·48	6·70	7·43	45
2 January 1942	III	7·81	5·80	3·96	3·69	4·54	5·16	25 December 1942	III	12·75	7·42	7·38	5·74	6·64	7·99	60
17 January 1942	IV	7·27	5·13	3·44	3·24	3·71	4·56	9 January 1943	IV	12·05	7·56	7·08	5·19	6·22	7·62	75
1 February 1942	V	6·07	4·40	2·82	2·74	2·81	3·77	24 January 1943	V	9·58	6·92	6·85	4·82	5·52	6·74	90
16 February 1942	VI	4·39	4·07	2·72	2·50	2·70	3·28	8 February 1943	VI	8·33	6·68	6·73	4·51	5·40	6·33	105
								23 February 1943	VII	8·23	6·51	6·61	4·28	5·26	6·18	120
Mean per plant	..	5·91	4·64	3·09	2·95	3·42	4·00	*Mean per plant*	..	9·10	6·37	6·26	4·55	5·40	6·34	..

TABLE II

Shows the analysis of variance of tiller numbers

1941-42						1942-43					
Due to	Degrees of freedom	sum of squares	Mean squares	F	P	Due to	Degrees of freedom	sum of squares	Mean squares	F	P
Blocks	4	18·4603	4·6151	..	..	Blocks	4	229·7694	57·4424	..	..
Varieties	4	189·5397	47·3849	13·72	·01	Varieties	4	411·2077	102·8019	76·78	<·01
Error(a)	16	55·2633	3·4540	..	..	Error (a)	16	265·5359	16·7210	..	..
Dates of observation	5	102·6022	20·5204	72·64	<·01	Dates of observation	6	595·8778	99·3129	74·13	<·01
Linear Compouent	1	0·0198	0·0198	..	..	Linear component	1	69·5772	69·5772	51·96	<·01
Quadratic component	1	87·1243	87·1243	308·40	<·01	Quadratic component	1	330·7328	330·7328	246·90	<·01
Residual component	3	15·4581	5·1527	..	..	Residual component	4	195·5678	48·8919	..	..
Interaction	20	27·8463	1·3923	4·93	<01	Interaction	24	108·6747	4·5280	3·38	<·01
Linear component	4	2·3782	0·5945	..	..	Linear component	4	8·5194	2·1298	..	..
Quadratic component	4	23·7468	5·9367	21·02	<·01	Quadratic component	4	69·2369	17·3092	12·93	<·01
Residual component	12	1·7202	0·1434	..	..	Residual component	16	30·9164	1·9322	..	..
Error(b)	100	28·2514	0·2825	..	..	Error (b)	120	160·6385	1·3386	..	..

(i) *Varieties*

The order of significance of the varietal differences for both seasons is as follows :

1941-42—							
Varieties .	Dhar selection	Rewa 42	Hyd. 557-10	Madhya Pradesh 137-7	Bansi 168	S. E.	Sig. diff.
Final number of tillers per plant	*4·39*	*4·07*	*2·72*	*2·70*	*2·50*	0·35	1·05
1942-43—							
Varieties .	Dhar selection	Hyd. 557-10	Rewa 42	Madhya Pradesh 137-7	Bansi 168	S. E.	Sig. diff.
Final number of tillers per plants	*8·23*	*6·61*	*6·51*	5·26	4·28	0·77	2·30

Significant differences were found among the varieties in both seasons. In the first season, both the Central India types, namely, Dhar selection and Rewa 42 were significantly superior to the outside types, namely, Hyd. 557-10, Madhya Pradesh 137-7 and Bansi 168, though the latter three types had no significant differences among themselves. In the second season, the differences among the varieties were not very sharp. Dhar selection was significantly superior to Madhya Pradesh 137-7 and Bansi 168 ; Hyd. 557-10 was intermediate between the two Central India types.

(ii) *Dates of observations*

The number of tillers counted on each date of observation was analyzed statistically and the order of significance of the differences for the two seasons is given below :

1941-42—

Number of days after sowing	60	75	45	90	105	30	S. E.	Sig. diff.
Number of tillers per plant	*5·16*	*4·56*	*4·51*	*3·77*	*3·28*	*2·73*	0·11	0·30

1942-43—

Number of days after sowing	60	75	45	90	105	120	30		
Number of tillers per plant	*7·99*	*7·62*	*7·43*	*6·74*	*6·33*	*6·18*	*2·08*	*0·23*	0·65

The mean number of tillers developed in each plant after 60 days of sowing was the highest in both seasons. In 1941-42, after the first count which was taken after 30 days of sowing, the rate of development increased significantly till the

maximum was reached which was after 60 days of sowing; later on, the tillers started dying off, and the rate of dying off increased significantly with the advance in the season till there were no further deaths; and the number of tillers survived became constant after 105 days and 120 days of sowing in 1941-42 and 1942-43 seasons respectively. It is interesting to note that the final number of tillers that survived was significantly higher than at the initial count in both seasons. The differences in the rate of development of tillers and their death in 1942-43 were not as sharp as in 1941-42 but the trend was similar.

The rate of tiller development was studied from counts of tillers taken at successive intervals. A smooth statistical curve was fitted to these counts to show the rate of tiller development graphically both for the average number of tillers and for the mean number of tillers of the individual varieties. The curve fitted was of the form: $Y=a+bx+cx^2+dx^3$...where Y is the expected number of tillers developed and x the dates of observation. As these dates were spaced at regular intervals that is, every 15 days in both seasons, use of orthogonal polynomials [Fisher and Yates, 1938] was made to fit the curve to any degree through successive stages. As the bulk of the sums of squares have been accounted for by the linear and quadratic components in both seasons, only the second degree curves have been fitted to all the five varieties and for the average number of tillers. The signs of linear regression coefficients are positive while those of the quadratic regression coefficients are negative in both seasons indicating that the average number of tillers increase upto a certain period and then begin to decrease till the number become constant.

The linear component was not significant in the first season but was highly significant in the second season indicating thereby that the average rate of tiller development was significantly more rapid in 1942-43 than in 1941-42. This significant difference in the two rates of tiller development may be explained by the fact that in the second season the average number of tillers after 45 days of sowing was about 4 times higher than those at the same period in the first season (Table I). It should be remembered that in the second season an extra irrigation was given after one month of sowing which was responsible for such a high increase in the number of tillers. The quadratic component was highly significant in both seasons, showing thereby that the average number of tillers get rapidly reduced after the maximum is reached.

The expected values of Y—average number of tillers developed per plant at each date of observation have been calculated from the statistical curve of second degree fitted to the observations (Fig. 1) and are given in Table III.

(iii) *Variation in the rate of tiller development of different varieties*

The mean square for interaction between dates of observation and varieties was highly significant in both seasons, which means that the differences in the number of tillers developed in the different varieties on given dates of observation are significant. But these differences on isolated dates of observation cannot tell us anything about the varietal differences in the general process of tiller development. The process of tiller development in any variety can be represented by a

TILLER FREQUENCIES

1941-42 & 1942-43 Seasons

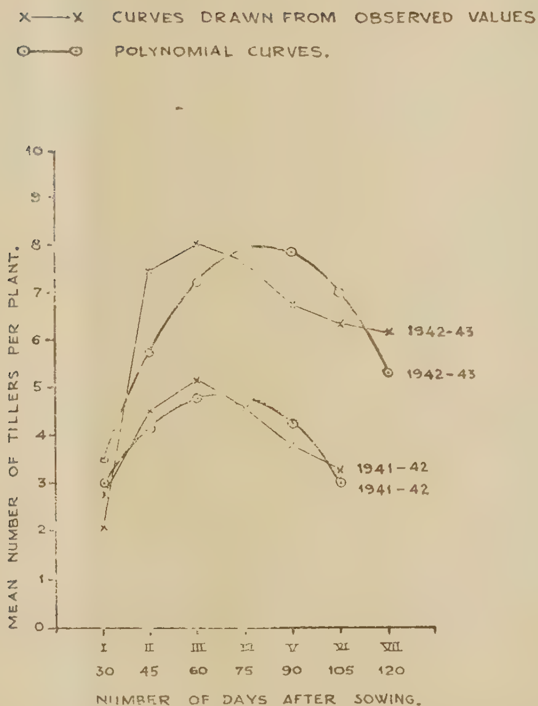

FIG. I. Mean number of tillers per plant for all varieties for the two seasons

TABLE III

Shows the expected values of tiller numbers (mean per plant)

1941-42							1942-43							
Dates of observation	Dhar selection	Rewa 42	Hyderabad 557-10	Bansi 168	Madhya Pradesh 137-7	Average over all varieties	Dates of observation	Dhar selection	Rewa 42	Hyderabad 557-10	Bansi 168	Madhya Pradesh 137-7	Average over all varieties	Number of days after sowing
3 December 1941	3·66	3·47	2·38	2·32	2·32	2·96	25 November 1942	4·20	3·47	3·28	2·76	3·32	3·41	30
18 December 1941	6·18	4·79	3·20	3·10	3·38	4·19	10 December 1942	8·35	5·59	5·38	4·23	5·00	5·70	45
2 January 1942	7·48	5·47	3·62	3·38	3·97	4·81	25 December 1942	10·99	7·01	6·81	5·17	6·07	7·22	60
17 January 1942	7·57	5·51	3·63	3·41	4·10	4·82	9 January 1943	12·12	7·75	7·58	5·59	6·57	7·93	75
1 February 1942	6·45	4·91	3·24	3·10	3·76	4·21	24 January 1943	11·74	7·79	7·70	5·50	6·48	7·85	90
16 February 1942	4·10	3·67	2·44	2·47	2·96	3·00	8 February 1943	9·85	7·15	7·14	4·87	5·81	6·97	105
							23 February 1943	6·44	5·83	5·93	3·73	4·56	5·30	120

statistical curve fitted to these observations for each variety, as was done in case of observations averaged over all varieties, and in terms of these varietal curves, the interaction would consist of the different components of the tiller curves being significantly different for the individual varieties. We, therefore, split the interaction degrees of freedom in the analysis of variance given in Table II. We thus get 4 degrees of freedom for the interaction—linear component x varieties. This interaction would show whether the average slope of the curves fitted to the individual varieties or in other words the average rate of tiller development in the different varieties differed significantly. Similarly the interaction of the quadratic component x varieties would show whether the curvatures of the curves fitted to the individual varieties were significantly different, thereby indicating significant differences in the rate at which the rate of tiller development slowed down in the different varieties with the progress of the season.

The linear component of the interaction was non-significant in both seasons showing thereby that the average rate of tiller development in the individual varieties was not significantly different from each other. On the other hand the quadratic component was highly significant in both seasons indicating significant differences in the rate of tiller death in the different varieties with the progress of the season after the maximum was reached in all the varieties. This significance of the quadratic component is mainly due to the higher death rate of tillers after the maximum was reached in Dhar selection as against the other varieties.

Comparing the varietal curves for the two seasons, they reflect the same differences as shown by the general curve, namely, that in 1942-43 season the rate of tiller development and their decrease were both much greater than in 1941-42 season. Comparing the curves of the individual varieties, the two curves of Dhar selection for 1941-42 and 1942-43 seasons are worth mentioning here. In both curves, the rate of tiller development and the fall, after the maximum was reached, were very rapid as compared to the remaining varieties, the resulting quadratic curve being distinctly different for this variety. Within the same period, the number of tillers produced were significantly the highest and their death rate was also highest. In the remaining varieties, the rate of development of tillers and subsequent deaths were more gradual thus forming a flatter curve than that of Dhar selection (Fig. 2). This is also seen from the regression coefficients given in Table IV. The regression coefficients for the quadratic component of Dhar selection is negative and significantly higher than that of other varieties in both seasons indicating significant drop in the slope of the curve due to deaths, as the season advanced.

Ear development

Ear emergence started about two months after sowing, that is, at the time when the maximum number of tillers had developed in the three outside varieties in 1941-42 and in Hyderabad 557-10 and Bansi 168 in 1942-43. The Central India varieties were about a week or fortnight later. Table V shows the progress of ear development in the five varieties in the two seasons. It will be seen from this table that the Central India varieties, namely, Dhar selection and Rewa 42 were definitely later

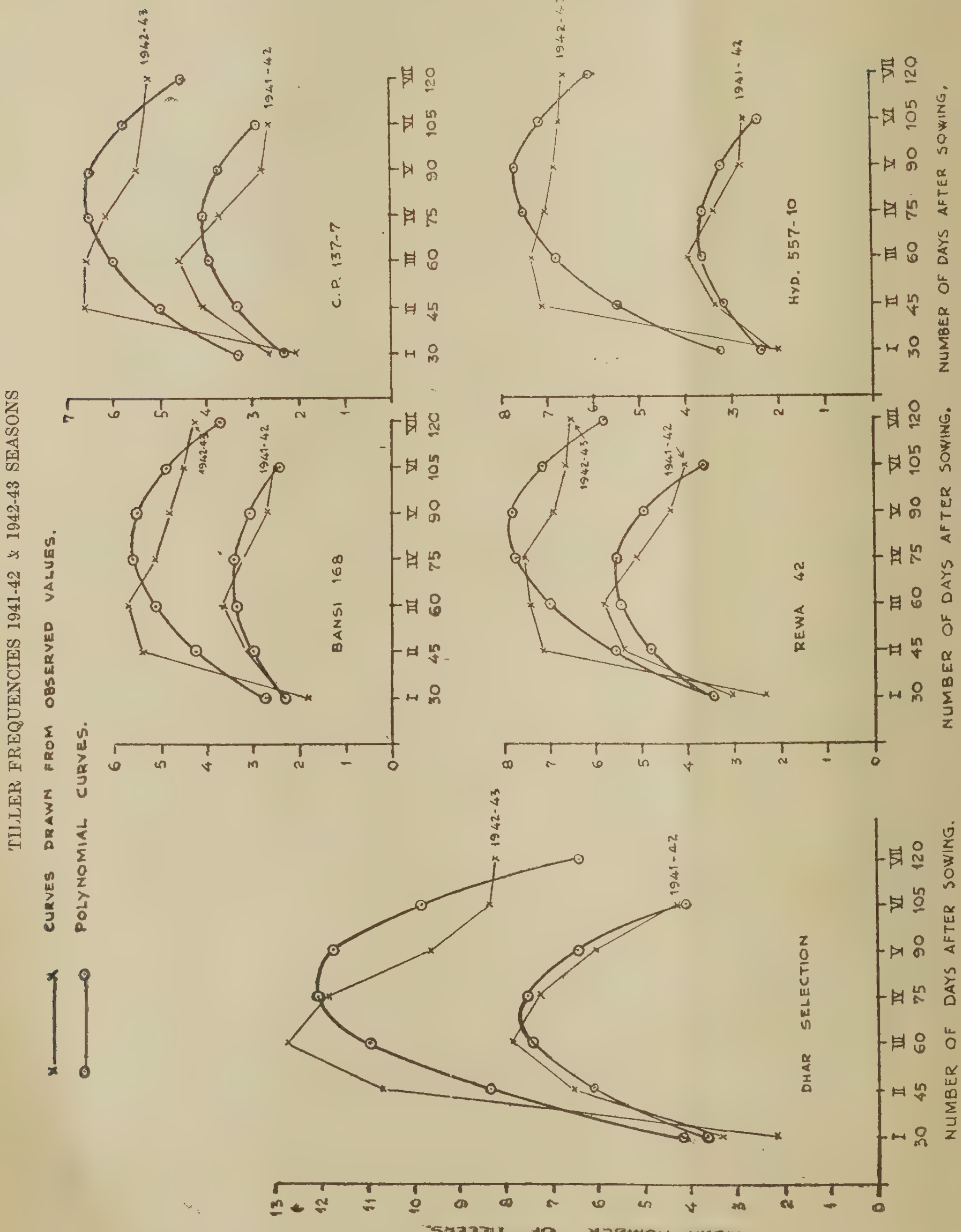

FIG. 2. Mean number of tillers per plant for the individual varieties for the two seasons

TABLE IV

Shows the regression coefficients and their standard error of the different varieties for tiller numbers

Varieties	Linear		Quadratic	
	1942-42	1942-43	1941-42	1942-43
Dhar selection	+0·0901	+·3742	—·6078	—·7554
Rewa 42	+0·0409	+·3923	—·3199	—·3442
Hyderabad 557-10	+0·0119	+·4419	—·2010	—·3312
Bansi 168	+0·0309	+·1617	—·1665	—·2612
Madhya Pradesh 137-7	+0·1285	+·2064	—·2322	—·2924
Standard error	0·0568	·0978	·0389	·0564

than the outside varieties, namely, Hyd. 557-10. Bansi 168 and Madhya Pradesh though the Central India. varieties were the first to develop tillers in 137-7 both seasons. Of the Central India varieties, Dhar selection was the latest of all varieties, but it produced the maximum number of ears in the same period in which the earlier ones (outside varieties) reached their maximum. The mean number of ears developed in each in 1942-43 was higher than in 1941-42 season indicating a higher average rate of ear development in the former season.

The development of ears at different dates of obseravtion was statistically examined and the analysis of variance for the two seasons is given in Table VI.

(i) *Varieties*

The order of merit of the varietal differences is given below :

1941-42—

Varieties	Dhar selection	Rewa 42	Hyderabad 557–10	Madhya Pradesh 137–7	Bansi 168	S. E.	Significant difference
Final number of ears harvested (per plant).	*4·34*	*4·04*	*2·62*	*2·48*	*2·38*	0·32	0·96

1942-43—

Varieties	Rewa 42	Dhar selection	Hyderabad 557-10	Madhya Pradesh 137-7	Bansi	S. E.	Sig. difference
Final number of ears harvested (per plant).	*5·73*	*5·65*	*5·51*	*4·17*	*3·13*	1·04	..

TABLE V

Shows the progress of ear development (mean per plant) in the five durum types

1941-42								1942-43								
Date of observation	Count	Dhar selection	Rewa 42	Hyderabad 557-10	Bansi 168	Madhya Pradesh 137-7	Mean per Count	Date of observation	Count	Dhar selection	Rewa 42	Hyderabad 557-10	Bansi 168	Madhya Pradesh 137-7	Mean per Count	Number of days after sowing
2 January 1942	I	0·00	0·00	1·22	1·13	0·65	0·60	25 December 1942	I	0·00	0·00	0·60	0·50	0·00	0·22	60
9 January 1942	II	0·10	1·21	1·98	1·70	1·88	1·38	1 January 1943	II	0·00	0·70	3·41	1·95	2·40	1·69	67
16 January 1942	III	0·92	2·90	2·30	2·06	2·43	2·12	8 January 1943	III	0·20	2·84	4·64	2·58	3·90	2·38	74
23 January 1942	IV	2·97	3·70	2·27	2·10	2·44	2·70	15 January 1943	IV	1·83	5·56	5·27	3·21	4·11	400	81
30 January 1942	V	4·47	3·89	2·45	2·17	2·43	3·08	22 January 1943	V	3·40	5·73	5·40	3·17	4·27	4·39	88
6 February 1942	VI	4·25	4·04	2·50	2·34	2·45	3·12	29 January 1943	VI	5·22	6·00	5·57	3·17	4·35	4·86	95
13 February 1942	VII	4·34	4·04	2·62	2·38	2·48	3·17	5 February 1943	VII	5·85	6·07	5·71	3·20	4·32	5·03	102
								12 February 1943	VIII	5·65	5·73	5·51	3·13	4·17	4·84	109
Mean per plant	..	2·43	2·82	2·19	1·98	2·11	2·31	*Mean per plant*	..	2·77	4·08	4·51	2·61	3·44	3·48	..

TABLE VI

Shows analysis of variance of ear numbers

1941-42						1942-43					
Due to	Degree of freedom	sum of squares	Mean squares	F	P	Due to	Degree of freedom	sum of squares	Mean squares	F	P
Blocks	4	6·7372	1·6843	..	..	Blocks	4	64·7052	16·1763	..	..
Varieties	4	15·4545	3·8636	1·92	..	Varieties	4	107·2834	26·8208	1·424	..
Error (*a*)	16	32·2044	2·0128	..	..	Error (*a*)	16	301·2078	18·8255	..	..
Dates of observation	6	149·2175	24·8696	153·90	< ·01	Dates of observation	7	537·5264	76·7895	85·17	< ·01
Linear component	1	132·0141	132·0141	817·00	< ·01	Linear component	1	458·3309	458·3309	508·0	< ·01
Quadratic component	1	16·8072	16·8072	104·00	< 01	Quadratic component	1	78·1109	78·1109	86·6	< ·01
Residual component	4	0·3961	0·0990	..	..	Residual component	5	1·0765	0·2153	..	..
Interaction	24	79·4726	3·3113	20·48	< ·01	Interaction	28	143·5966	5·1284	5·68	< ·01
Linear component	4	59·1307	14·7827	91·43	< ·01	Linear component	4	73·3948	18·3487	20·3	< ·01
Quadratic component	4	5·0939	1·2735	7·87	< ·01	Quadratic component	4	30·0396	7·5099	8·33	< ·01
Residual component	16	15·2481	0·9530	..	..	Residual component	20	40·1622	2·0081	..	..
Error (*b*)	120	19·3974	0·1616	..	..	Error (*b*)	140	126·2259	0·9016	..	..

In 1941-42 season, the two Central India varieties were significantly superior to the outside varieties in the final number of ear heads harvested, but these three in turn had no significant differences among themselves. In the second season on account of high standard error, the differences among the varieties were not significant though the trend of the differences was the same as in 1941-42.

(ii) *Dates of observa tion*

Order of significance of the different dates of observation on which ear counts were taken is given below :

1941–42—

									S. E.	Significant difference.
Number of days after sowing		102	95	88	81	74	67	60		
Number of ears developed per plant		*3·17*	*3·12*	*3·08*	*2·70*	*2·12*	*1·38*	*0·60*	0·08	0·23

1942–43—

									S. E.	Significant difference.
Number of days after sowing	102	95	109	88	81	74	67	60		
Number of ears developed per plant	*5·03*	*4·86*	*4·84*	*4·39*	*4·00*	*2·83*	*1·69*	*0·22*	0·19	0·54

In both seasons, mean number of ears developed were maximum after 102 days of sowing. After the appearance of the first ear heads the rate of development of ears increased significantly on each successive counts till about 88 days after sowing, and though fresh ears continued to develop, the rate afterwards slowed down till the number of ears became constant which was after 102 and 109 days of sowing in 1941-42 and 1942-43 seasons respectively.

Like tiller development, the rate of ear development was studied graphically. Only the linear and quadratic components of the curve have been calculated as they account for the entire sums of squares for dates, and these sums of squares are given in Table VI. These components are highly significant in both seasons indicating that the rate of ear development was significantly different at each date of observation and later on it changed significantly with the change in the season. The average number of ears expected at various intervals have been calculated from the statistical curves of the second degree fitted to the observations and are given in Table VII and the curves are drawn in Fig. 3.

(iii) *Variation in the rate of ear development of different varieties*

The mean square for interaction between dates of observation and the varieties was highly significant in both seasons, showing thereby, that the differences in the number of ears developed in the different varieties on any given dates were highly significant. The process of ear development could also be represented by a statistical curve. The degrees of freedom have therefore been split up into linear and quadratic components as was done in case of tillers. The sums of squares

EAR FREQUENCIES

1941-42 & 1942-43 Seasons

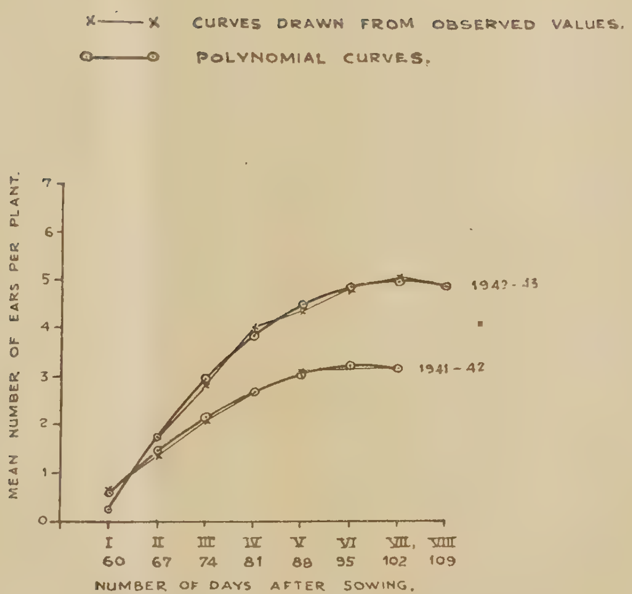

Fig. 3. Mean number of ears per plant for all varieties for the two seasous

TABLE VII

Shows the expected value of ear numbers (mean per plant)

1941-42							1942-43							
Dates of observation	Dhar selection	Rewa 42	Hyderabad 557-10	Bansi 168	Madhya Pradesh 137-7	Average over all varieties	Dates of observation	Dhar selection	Rewa 42	Hyderabad 557-10	Bansi 168	Madhya Pradesh 137-7	Average over all varieties	Number of days after sowing
2 January 1942	—0·61	—0·07	1·37	1·22	0·88	0·56	25 December 1942	—0·91	—0·61	1·14	0·74	0·48	0·21	60
9 January 1942	+0·65	+1·49	1·81	1·62	1·63	1·44	1 January 1943	+0·21	+1·58	2·87	1·71	2·06	1·69	67
16 January 1942	1·77	2·68	2·15	1·93	2·18	2·14	8 January 1943	1·30	3·36	4·21	2·47	3·27	2·90	74
23 January 1942	2·63	3·54	2·39	2·15	2·52	2·67	15 January 1943	2·35	4·70	5·18	3·00	4·12	3·83	81
30 January 1942	3·55	4·02	2·53	2·29	2·65	3·01	22 January 1943	3·37	5·61	5·76	3·32	4·60	4·49	88
6 February 1942	4·21	4·16	2·58	2·35	2·58	3·18	29 January 1943	4·35	6·09	5·96	3·41	4·71	4·88	95
13 February 1942	4·73	3·94	2·53	2·32	2·31	3·17	5 February 1943	5·29	6·15	5·77	3·28	4·45	4·91	102
							12 February 1943	6·20	5·77	5·20	2·93	3·84	4·84	109

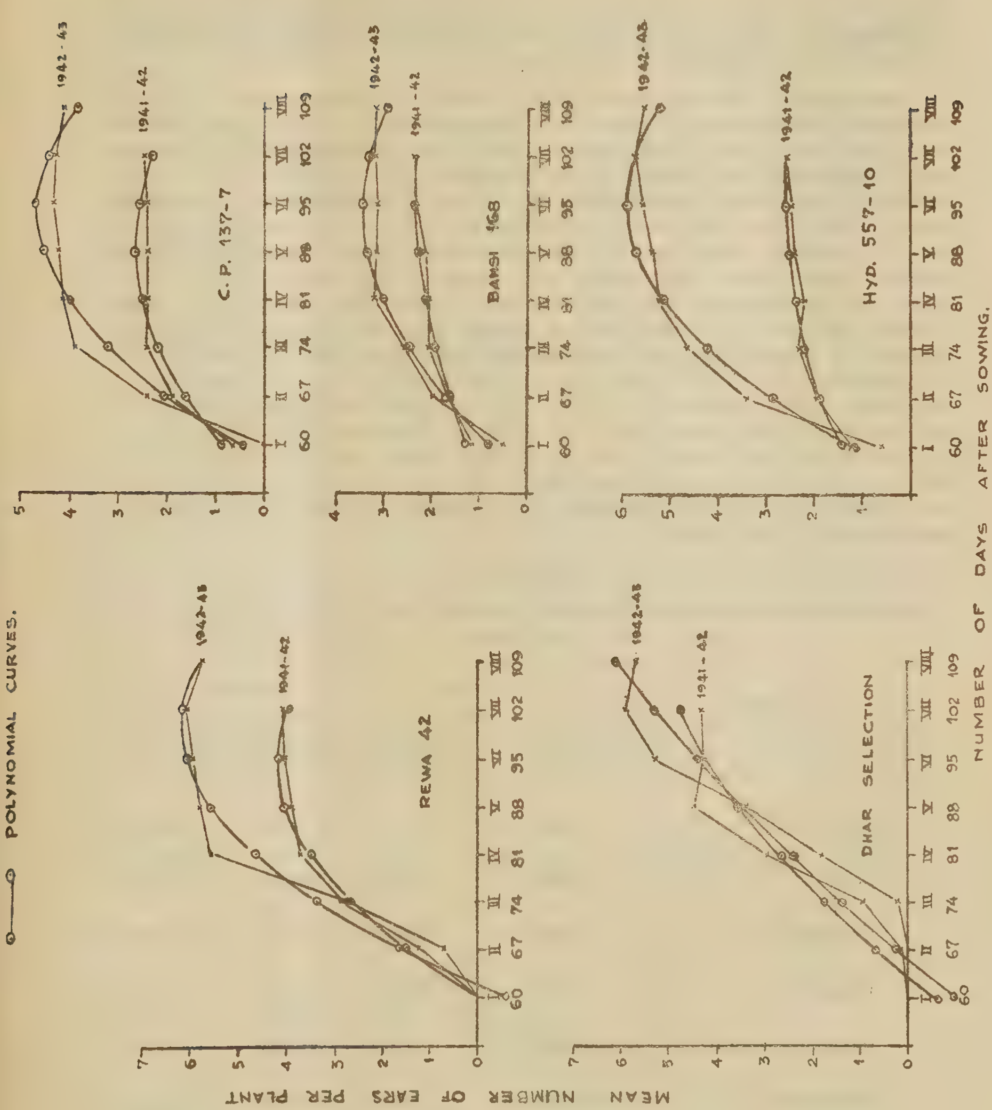

FIG. 4. Mean number of ears per plant for the individual varieties for the two seasons

are given in Table VI. These two components were highly significant in both seasons, which means that the rate of ear development was significantly different in the different varieties and that this rate had changed significantly in the different varieties with the progress of the season.

Comparing the curves of the individual varieties for the two seasons (Fig. 4), we find that the curves are steeper in 1942-43 season than in 1941-42 season indicating a higher rate of ear development in each of these varieties. These varieties formed themselves into different groups according to the steepness of the curves. In 1941-42 season Dhar selection formed into a group by itself, Rewa 42 in the second group and the three outside varieties into the third group. The rate of ear development was highest in Dhar selection, then came Rewa 42 and the three outside varieties formed almost horizontal curves indicating a poor rate of ear development. In 1942-43 season the varieties again formed into three groups, Dhar selection and Rewa 42 forming the first group Hyderabad 557-10 and Madhya Pradesh 137-7 forming the second and Bansi 168 forming the third. The rate of ear development was heigher in the two Central India varieties, intermediate in the second group and least in the third. The regression coefficients (Table VIII) also indicate the above conclusions. The regression coefficients for linear component of Dhar selection and Rewa 42 were significantly higher than those of the outside varieties in both seasons, indicating a higher rate of ear development in the Central India varieties, those of Hyderabad 557-10 and Madhya Pradesh 137-7 intermediate and of Bansi 168 the lowest.

TABLE VIII

Shows the regression coefficients and their standard error of different varieties for ear numbers

Varieties	Linear		Quadratic	
	1941-42	1942-43	1941-42	1942-43
Dhar selection	+0·8894	+1·0170	+0·0746	—0·0178
Rewa 42	+0·6691	+0·9122	—0·1782	—0·2146
Hyderabad 557-10	+0·1926	+0·5811	—0·0490	—0·1913
Bansi 168	+0·1823	+0·3141	—0·0424	—0·1107
Madhya Pradesh 137-7	+0·2373	+0·4791	—0·1028	—0·1831
Standard error	0·0339	0·0655	0·0196	0·0327

(v) Number of grains per ear

Mean number of grains per ear were calcuated for the two seasons and the data were analyzed statistically. The order of significance of the varietial differences is given below :

1941–42

Varieties	Madhya Pradesh 137–7	Bansi 168	Hyderabad 557–10	Rewa 42	Dhar selection	S. E.	Significant differences
Mean number of grains per ear	22·9	22·7	19·8	17·4	15·9	1·3	3·9

1942–43

Varieties	Bansi 168	Hyderabad 557–10	Madhya Pradesh 137–7	Rewa 42	Dhar selection		
Mean number of grains per ear	27·0	26·2	23·6	17·8	13·1	1·4	4·1

In both seasons, the varieties formed into two groups, the outside varieties in the higher group and the Central India varieties in the lower group. Differences between the two groups were significant in both seasons except that in 1941-42 season, Hyderabad 557-10 was not significantly higher than Rewa 42. These differences show that the Central India varieties have fewer grains per ear than the outside varieties, all of which have higher grain number per ear.

Weight per 100 grains

Mean weight per 100 grains per plant was calculated for each variety and the data were analyzed statistically. The order of significance of the varietal differences is given below :

1941–42

Varieties	Dhar selection	Rewa 42	Bansi 168	Hyderabad 557–10	Madhya Pradesh 137–7	S. E.	Significant differences
Mean weight (gm.)	5·18	4·89	4·39	4·32	3·87	0·14	0·42

1942–43

Varieties	Rewa 42	Dhar selection	Madhya Pradesh 137–7	Hyderabad 557–10	Bansi 168		
Mean weight (gm.)	5·41	4·92	4·75	4·59	4·46	0·19	0·57

The varieties have again formed themselves into two groups. The Central India varieties forming into the higher group and the outside varieties into the lower group. The Central India varieties have significantly heavier seed weight than the outside varieties.

Yield of grains in both seasons.

Mean yield of grains from the sampling units and the whole plots is given below :

Varieties	Sampling units 1941-42 (mean per plant)	Sampling units 1942-43 (mean per plant)	Whole 1942-43 (mean per plot)
Dhar selection	14·8 gm.	18·6 gm.	16·6 oz.
Rewa 42	17·8 „	25·8 „	16·2 „
Hyderabad 557–10	10·5 „	26·6 „	15·6 „
Bansi 168	12·1 „	16·1 „	12·4 „
Madhya Pradesh 137–7	11·1 „	22·5 „	13·4 „
Standard error	2·7	5·7	0·8
Standard error percent	20·7	26·0	5·2
Significant difference	..	..	2·4 oz.

Yield of grains from whole plots was not taken in 1941-42 season, but only yield from individual plants from each of the sampling units was collected. In the second season yield from both whole plots and sampling units was obtained separately. The data for the two seasons were analyzed statistically and are given above.

Owing to a high sampling error in both seasons, no significant differences were found among the varieties in the yield of grain from the sampling units but in the former season, the differences in the mean yield of grains between the Central India group and outside group approached significance. Differences in the yield of grains from whole plots in 1942-43 were significant both among the varieties and between the two groups (critical difference between groups was 1·51 oz.). Dhar selection inspite of rat damage had done better than the outside varieties.

Conclusions.

The Central India varieties, namely, Dhar selection and Rewa 42 were found to be superior to the outside varieties, namely, Hyderabad 557-10, Madhya Pradesh 137-7 and Bansi 168 in the number of tillers and ears per plant but were late by about a week or more in producing ear heads. They were also higher in weight of

100 grains and total yield of grains per plant but were found to be poorer in number of grains per ear. This deficiency seemed to have been compensated by the heavier seed weight and higher tiller and ear number resulting in higher yield of grain. Simlote [1947] while working out a discriminant function for selection in *durum* wheats also found grain weight in addition to tiller number to be highly correlated with the genetic yield potentiality of the variety but the number of grains per ear, on the other hand, was negatively correlated.

The two seasons' results showed that the Central India varieties were well adapted to the local conditions of growth but the response of the outside varieties was found to differ according to the character of the season. Hyderabad 557-10 which was poorer in the first season than the Central India varieties came up to their level in the second season which was more favourable, while Bansi 168 and Madhya Pradesh 137-7 did not respond to the better seasonal conditions and remained poorer in both seasons.

These studies have indicated that in order to evolve high yielding varieties for Malwa, selection should be resorted to in the locally adapted material which is already at a higher level in yield attributes as compared to outside varieties, provided there is sufficient genetic variability present in the material for selection to be effective. It has, however, been found by Simlote [1949] that there is very little genetic variability present in the local material. Success can, therefore, only be achieved if genetic variability could be created by crossing local types with the outside varieties and then making selection in the hybrids.

Summary

Developmental studies of five ecological types from Central India (now Madhya Bharat), Madhya Pradesh, Bombay and Hyderabad State were undertaken for two seasons 1941-42 and 1942-43 with a view to study differences in their yield attributes.

A replicated trial was laid out in each season with five randomised blocks. Fortnightly counts of tillers beginning at one month after sowing and weekly counts of ear heads beginning with the appearance of first ear heads were taken and continued until the number of each was found to be constant, in each season on plants in three foot lengths selected at random in each plot.

The data thus collected were analyzed statistically and statistical curves were also fitted to these observations by means of polynomials. After harvest, mean number of grains per ear, weight per 100 grains and total yield of grains were also calculated and analyzed statistically.

The Central India types were found superior to the outside types in total yield of grains, mean weight per 100 grains, growth rates of tillers and ear heads, but were inferior to the outside types in mean number of grains per ear.

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REFERENCES.

Fisher, R. A. and Yates, F. (1938). *Statistical Tables for Biological Agricultural Medical Research,* Oliver and Boyd London

Fisher, R. A. (1938). *Statistical Methods for Research workers,* Oliver and Boyd London

Hutchinson, J. B. and Panse, V. G. (1936). The introduction of improved strains of crop plants in Central India and Rajpntana. *Jour. Agri. and Livestock India,* **VI,** 397

Simlote, K. M. (1947). An application of discriminant function for selection in *durum* wheats. *Indian agri. Sci.* **XVII,** 269

———— (1949). A study of Genetic variability in Central India *durum* wheats *Proc. Ind. Aca. Sci.* **XXX,** I

LOSSES IN MAKING BERSEEM (EGYPTIAN CLOVER) HAY AND SILAGE *

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FIELD-CURING of hay under ordinary conditions is always accompanied by appreciable losses which are confined in respiration of the crop, mechanical injury, fermentation in the stack, effect of weather conditions such as dew and rain, destruction of carotene and losses of other vitamins. Many investigators e.g., Wiegner [1934], Landis [1932], Edin [1931] and Watson [1937] have found that the total losses of dry matter during hay-making varied from 10 to 30 per cent, of digestible dry matter 15 to 35 per cent, of digestible proteins 20 to 40 per cent and of starch equivalent from 25 to 50 per cent. Wiegner *et al.* [1923] by studying the losses of hay dried in the ordinary way (on ground) came to the following conclusions : In very favourable to a favourable weather conditions, the loss during hay-making in Switzerland reached two fifths (2/5) of the starch equivalent and one third (1/3) of the digestible protein from the day of cutting to the day of feeding animals on the hay. In the case of moderate weather, Wiegner found that the loss reached two thirds (2/3) of both the starch equivalent and the digestible protein Because of these appreciable losses, the tendency at present appears to be toward making silage to maintain the greatest nutritive value possible and reduce losses to a minimum. Silage generally retains a greater portion of the nutritive value of the green plant. The losses which silage undergoes depend largely on the method of ensiling. Völtz *et al.* [1924, 1925] found that the losses in making sweet silage without additions were 5·1 per cent in organic matter, 10·4 per cent in starch equivalent and a gain of 13·60 per cent in digestible proteins. Crasemann [1926] found that the losses were 35·7 per cent in starch equivalent and 35·6 per cent in digestible proteins while Kleiber [1924] found a loss of 16 per cent in dry matter and 13 per cent in crude proteins. Wiegner [1934] reported that the losses in the A. I. V. silage made by the addition of mineral acids were found to be 24·9 of digestable proteins and 8·08 per cent starch equivalent. He noted that the A. I. V. silage was superior to other types of silage because of its lowest losses.

This work has therefore been done to measure the losses in the different ingredients of berseem hay and silage during their making by the different methods already discussed by the same authors in a separate paper [1949].

Losses in field-cured hay

Under practical conditions, the best way to reduce the losses in making berseem hay to a minimum is by cutting berseem in the morning after the dew is off, aan the

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necessary handling in its making should take place as much as possible before the leaves are dry enough to shatter. It is known that when legumes reach a certain stage of dryness the leaves shatter readily. In the case of alfalfa, Zink [1936] estimated this stage to be when the residual moisture was 30 per cent or less. This limit in berseem was found to be 35 per cent and attained in the average after four days in the second cutting and three days in the third one. Stored hay with more moisture content than usual will markedly lose its colour. Egyptian farmers have the experience to know when the hay is dry enough to be moved and stacked and also the stage when the leaves become ready to be shattered. This means that to reduce to a minimum the loss of leaves—that portion of the crop richest in dry matter, proteins, vitamins and minerals—handling should take place as much as possible before leaves are ready enough to shatter. When berseem moisture becomes less than 35 per cent handling should be done carefully so as to reduce loss due to shattering as much as possible.

The general results obtained of losses in field-cured berseem hay in the year 1944 are summarized in Table I.

Table I

The general results obtained of losses in field-cured berseem hay in 1944

Berseem hay how and where dried	Losses in						
				Digestible			
	Percentage of dry matter	Percentage of organic matter	Percentage of crude proteins	Percentage of dry matter	Percentage of organic matter	Percentage of proteins	Percentage of starch equivalent
1—Hay of second cutting (1944) (Weight of a single bundle=1 kg.)							
a—Unbundled sun-dried	20·24	20·49	19·15	38·31	38·84	35·07	47·30
b—Bundled sun-dried	32·36	29·98	37·33	47·48	46·14	49·62	56·10
c—Unbundled shade-dried	15·12	12·85	20·77	34·09	32·96	36·31	46·83
d—Bundled shade-dried	21·80	20·23	31·27	39·29	38·64	44·77	52·43
2—Hay of third cutting (1944) (Weight of a single bundle= 0·5kg.)							
a—Unbundled sun-dried	21·40	19·89	32·43	34·16	24·99	42·59	43·94
b—Bundled sun-dried	21·00	20·06	27·05	29·53	25·14	38·05	43·51
c—Unbundled shade-dried	16·46	16·16	35·40	25·48	21·49	45·05	42·79
d—Bundled shade-dried	22·86	23·13	34·47	31·20	26·69	44·22	37·53
3—Total average of the two cuttings in years 1944 and 1945							
	20·97	20·01	33·41	30·28	29·54	40·52	46·53

1—Second cutting:
Average yield of berseem per feddan (4200^2 meters)-5494 kg.
Average yield of hay per feddan (4200^2 meters)=1118 kg.

2—Third cutting:
Average yield of berseem per feddan (4200^2 meters)=5350 kg.
Average yield of hay per feddan (4200^2 meters) =1091 kg.

It can be easily noticed from the data of Table I that in the unbundled hay of second cutting the losses are less than in the bundled type whether dried in the shade or in the sun. As the weight of the bundle was decreased from 1 kg. in the second cutting to half this weight in the third cutting, the losses in the bundled type became nearer to those of the unbundled hay. This might be due to the fact that poor aeration in bigger bundles favours factors causing losses during curing. It was noticed in most cases that the inner parts of the bundles mold and ferment. On the other hand, there is less loss in the shade-dried hay of the unbundled form in either second or third cutting than in the sun-dried with the exception of crude and digestible proteins where the former exceeds slightly the latter. Therefore, the unbundled shade-dried hay is superior to all the different types.

Comparing the losses of the second cutting to those of the third cutting, it appeared that there is less in the latter, generally speaking, than in the former; and from the starch equivalent point of view this statement is quite true and hence the third cutting berseem is preferred in hay-making.

As shade-drying is impractical in Egypt for it needs special care, more labour and more time, it seems, from the economical point of view, that the unbundled sun-dried hay is preferred especially for the preservation of crude and digestible proteins. The slight difference in losses between it and the shade-dried form of the unbundled type in the other ingredients is considered insignificant.

The average losses that took place in hay-making are shown in Table 1:—21 per cent of dry matter, 20 per cent of organic matter, 33 per cent of crude proteins, 30 per cent of digestible dry matter, 30 per cent of digestible organic matter, 41 per cent of digestible proteins and 47 per cent of starch equivalent. The minimum losses were found to be 1/7, 1/7, 1/5, 1/4, 1/5, 1/3 and 1/3 respectively. This agreed well with the figures obtained by Wiegner [1934] who found that in favourable conditions for making hay the loss reached 2/5 of starch equivalent and 1/3 of digestible proteins. Landis and co-workers [1932] found these losses in the average 33 per cent and 42 per cent respectively where Edin and associates [1931] found them 29 per cent and 28 per cent. Watson [1937] found that under average conditions of hay-making in the British Isles the losses in feed value from harvesting to storing in stacks may amount to 30 per cent or more of the starch equivalent and digestible proteins and in the unfavourable weather these losses may even exceed 50 per cent. These figures indicate that in favourable weather conditions, losses in field-curing berseem hay in Egypt generally approximate those which take place in making hay from legumes and other crops.

Losses in silage-making

The total losses of different ingredients in making berseem silage have been studied in both the second and third cuttings in the year 1944. Silage was made as has been already mentioned in a previous paper by four different methods :—1—without additions, 2—with the addition of 1 per cent and 3 per cent molasses, 3—by the wilting or partially-dried method, and 4—by the acid or A. I. V. process. The general results obtained of losses in making different kinds of berseem silage with comparison to those in making berseem hay are shown in Table II.

TABLE II

The general results obtained of losses in making different kinds of berseem silage with comparison to those in making berseem hay

Items	Losses in							Average		
	Percentage of dry matter	Percentage organic matter	Percentage of crude protein	Digestible			Starch value	pH	Percentage lactic acid	Percentage of butyric acid-free and combined.
				Percentage dry matter	Percentage of organic matter	Percentage proteins				
	1—*Silage and hay of second cutting (1944)*									
A—*Silage of*										
a—'Nothing-added'	34·03	35·93	24·70	71·28	68·09	48·88	79·84	5·90	0·25	1·55
b—One per cent molasses.	29·19	31·96	36·71	62·30	72·49	71·93	80·19	5·30	0·30	1·93
c—Partially-dried	14·65	15·43	18·43	35·69	42·93	47·44	55·24	4·46	0·43	1·40
d—A.I.V.	4·38	2·29	0·00	27·00	22·31	28·93	20·76	3·95	0·58	0·14
B—*Unbundled shade-dried hay.*	15·12	12·58	20·77	34·09	32·96	36·31	46·83	..	..	..
	2—*Silage and hay of third cutting (1945)*									
A.—*Silage of*										
a—'Nothing-added'	21·95	26·76	40·93	59·03	59·53	64·88	72·26	5·90	0·27	1·45
b—3 per cent molasses	29·84	33·28	45·58	61·08	59·88	44·50	67·30	5·20	0·38	0·45
c—Partially-dried	4·93	9·37	25·20	40·20	39·08	39·16	53·00	4·51	0·43	0·95
d—A. I. V.	6·99	7·21	17·09	29·05	23·16	24·88	26·93	4·04	0·54	0·18
B—*Unbundled shade-dried hay.*	16·46	16·16	35·40	25·48	21·49	45·05	42·79	..	..	...

1—Second cutting:
Average yield of berseem per feddan (4200^2 meters) = 5494 kg.
Average yield of silage per feddan (4200^2 meters) = 4143 kg.
2—Third cutting:
Average yield of berseem per feddan (4200^2 meters) = 5350 kg.
Average yield of silage per feddan (4200^2 meters)—4133 kg.

The acidity of silage depends on the amount of water-soluble carbohydrates in the plants. According to Woodward [1938] it appeared that there are factors other than the contents of soluble carbohydrates that have a bearing on the quantity of acid developed in the silo. The acidity unquestionably influences the character of fermentation. Wiegner [1923, 1934] studied the effect of acidity on the presence of organic acids; it appeared that silage with high acidity (low *p*H) is lower in volatile acids (chiefly acetic acid) but high in residual acidity (lactic acid). The more lactic acid and the less acetic and butyric acids formed in silage, the better, as a rule, the silage is.

From Table II, it is worthy to note that the A. I. V. silage was superior to all other kinds of silage in having the highest acidity (less than *p*H 4), with highest amounts of lactic acid (0·54 to 0·58 per cent) and smallest of butyric acid free and combined (0·14 to 0·18 per cent), and had also the least losses of all the different

constituents in both second and third cuttings (with the exception of dry matter in the third cutting). These losses in case of A. I. V. silage were even less than the lowest occurring during field-curing of hay under the most favourable conditions in Egypt. For example, the lowest losses during hay-making were found to be 42·79 per cent of starch equivalent in third cutting berseem hay and 36·31 per cent of digestible proteins in second cutting hay. The average losses in making berseem hay were found to be 46·53 per cent of starch equivalent and 40·52 per cent of digestible proteins (Table I). Therefore, the losses in making A. I. V. berseem silage were less than those in other types of silage and in field-cured hay. One of the authors (A. G.) has previously found that the losses in making ordinary berseem hay made by the Egyptian farmers were as high as 70·23 per cent of digestible proteins and 69·39 per cent of the starch equivalent. This means that the losses in making ordinary hay by the farmers were three or four times as much as those in A. I. V. silage making. Besides that, Wiegner [1934] found that the losses in silage ensiled in small experimental silos were greater than those obtained in big silos. There were in the former 10·87 per cent of digestible proteins and 22·74 per cent of starch equivalent; and in the latter 3·44 per cent and 7·64 per cent respectively. In another case, he found that the losses in making A. I. V. silage in the experimental basin were 24·90 per cent of digestible proteins and 8·08 per cent of the starch equivalent whereas they were in the big silo 15·90 per cent and 3·15 per cent respectively. These figures show that it is possible even to minimize the small losses found in the A. I. V. silage by ensiling in big basins.

It can, therefore, be concluded that the A. I. V. process is the best and most advisable method for making berseem silage in Egypt. On the other hand, A. I. V. as well as the partially-dried types of silage are also superior to the kind of hay that is found to be of least losses.

Summary

In Egypt, it was found that the clover (berseem) leaves shattered readily when the moisture content became 35 per cent; this was attained after four days in the second cutting and three days in the third one. The less is in unbundled hay of second cutting less than in the bundled type whether dried in the shade (15·12 per cent) or in the sun (20·24 per cent). The unbundled shade-dried hay is superior to all other types in either second (15·12 per cent) or third cutting (16·46 per cent). The third cutting is preferred in field-curing of hay for its less losses. The A. I. V. silage was found to be superior to all other kinds of silage in being of least losses (4·38 per cent) and even to the unbundled shade-dried type of hay (15·12 per cent). It is also superior in having the highest acidity (pH 3·95), highest lactic acid (0·58 per cent) and lowest butyric acid content (0·14 per cent).

REFERENCES

Crasemann, E. (1926). Einleitende Untersuchungen uber die Konservierung und den Futterwert von Obsttrestern. *Landw. Jahrb. der Schweiz*, **40**, *Jahrg.*, S. 914-930

Edin, H., N. Berglund und Y. Anderson (1931). *Meddelande* No. 399 *från Centralanstalten för försörksväsendet på jordbruksområdet Hudsjursavadelingen* No. 76

Ghoneim, A., M. T. El-Katib and M. M. Badr (1949). The Nutritive Value of Green Berseem (Egyptian Clover), Its Hay and Silage. *J. Anim. Sci.* 8, No. 2, 279 to 285

Kleiber, M. (1924). Uber die elektrische konservierung von saftigem futter (Elektrosilierung), *Promotions arbeit Nr.* 363 *der Eidg. Techn. Hochschule, Zurich*

Landis, J. (1932). Unter Mitrarbeit von H. Burckhardt und E. Steiner. Vergleichende versuche zur Verbesserung der Dürrfutterbereitung. *Schweiz. Landw. Monatshefte*, 10. *Jahrg.*, S. 282-288, 293-302, 314-319

Völtz, W., E. Reisch und H. Jantzon. 1924. Uber die Verluste des Rotklees an Rohnährstoffen verdaulichen Nahrstoffen und Stärkewert bei der Normalsauerfutterbereitung. *Mitt. der* D. I. G., Jahrg. 27, 479

——, —— und —— (1925), *vgl. auch. Arbeiten der Deutschen Landw. Gesellsch aft.* 340

Watson, S. J. (1937). The Losses involved in the Conservation of Grassland Herbage and Their Determination. 4th. *Internatl. Grassland Cong., Gt. Brit.*, July 8-23, *Rept.*, 417-421

Wiegner, G. (1934). Heubereitung und Silage. Verhandlungsbericht des III. *Grunland-Kongress nord und mitteleuropäischer Lander in der Schweiz*, S. 320-383

Wiegner, G., E. Crasemann und J. Magasanik (1923). *Untersuchungen über Futterkonservierung.* 1. *Das sog. Sussgrünfutter. Landw. Versuchsstationen, Bd.* 100, S. 143-268

Woodward, T. E., Shepherd (1938). Methods of Making Silage from Grasses and Legumes. *U.S. Dep. Agr. Tech. Bull.* 611, 34 *illus*

Zink, F. J. (1936). Moisture Content at which Alfalfa Leaves shatter. *Agr. Engin.* 17, 329-330, *illus*

TOLERANCE OF DIFFERENT CROP AND VEGETABLE SEEDS TO VARIOUS REACTIONS OF H-ION CONCENTRATIONS

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(With four text-figures)

THAT the reaction of the medium is an important factor influencing the growth of the plant has been shown by a number of workers. Arrhenuis [1922] studied the growth of crop plants in media of varying H-ion concentration ranging from *p*H3 to *p*H10 and found that there were two *p*H values at which the highest yield in each crop was recorded. Olsen [1923] has shown the significance of a definite *p*H range in the natural distribution of plants. According to Hoagland [1926] slight acidity *p*H5 to *p*H7 is not in itself injurious to various types of plants but alkaline solutions above *p*H8 prove less favourable to most agricultural plants. It will be thus seen that considerable study has been devoted to unravelling the relationship of H-ion concentration to growth of plants. Less attention, however, seems to have been paid to the influence of the H-ion concentration of the medium upon germination and early seedling growth. It was therefore, considered desirable from a practical stand point to determine to what extent soil acidity or alkalinity produce an injurious or favourable influence on germination of crop seeds, and what range of acidity or alkalinity would be tolerated by different crop seeds so that it may be possible to make certain practical recommendations to farmers. Such a study is designed to show, when the vegetable farmer or crop grower can afford after a preliminary test of the *p*H of the soil to put his seeds in that soil without risk of failure of germination. If the preliminary examination of the *p*H of the soil discloses a value of *p*H within the range of *p*H values to which tolerance has been shown by that crop or vegetable seed, the farmer need not be worried about any expensive treatment to make suitable changes in the *p*H in the soil. If on the other hand the preliminary test of the *p*H of the soil reveals a value outside range of tolerance exhibited by that seed or a group of seed, he has to take steps to make suitable adjustments in the *p*H of the soil, while most farmers are interested in raising an average crop, the most ambitious among them are interested in getting the highest yields out of the crop at the minimum cost. Such farmers obviously would also like to know the optimal *p*H value at which maximum germination percentage would result. This study is designed to answer both these types of questions as far as possible.

Experimentation

Seeds of uniform size, weight, and relative density as far as possible were sterilized by 0·1 per cent mercuric chloride solution for about 5 minutes. These were then washed with sterilized distilled water being given six changes spread over about half an hour in all, laid over blotting paper and finally dried in the sun. Each kind of

c p .ced was put for germination in solutions of 7 different pH values with 4 replications in each particular pH. The pH values ranged between pH4 and pH10. Each of the enamelled dishes, in which germination tests were carried out, contained usually 100 or 50 seeds depending on the quantity of seeds available. The dishes were placed under natural conditions excepting that there was a wire enclosure to prevent the attack of birds. Seeds were spread on a good white blotting paper thoroughly moistened with solutions of the desired pH. A fresh solution was added after every 24 hours, after washing the dishes with sterilized distilled water. The varying H-ion concentrations were maintained in this manner and seeds sprouting were recorded at 12-hour intervals, the sprouted seeds being thrown out each time.

The variation in pH values was brought about by the use of Merck's hydrochloric acid and sodium hydroxide with which normal solutins were prepared first which were diluted later to yield the desired pH. *Walf's pH tester* was used to determine the pH of each solution.

The crop seeds for this study included wheat (varieties N. P. 4, 12, 52, 165 and C. 518) ; oats local, barley (var. B. 16, C. 52, T. 41) ; linseed local ; safflower local, pigeon pea ; gram ; paddy (var. N. 22, T. 64, T. 136) ; sugarcane Co. 312 ; the vegetable seeds included, lady's finger local, bottle-gourd (local).

The results obtained have been statistically evaluated in each case by carrying out analysis of variance.

Experimental findings

Total germination percentage. In the present investigation, it was noticed that each crop gave good germination at one pH but in some cases at more than one.

Wheat. Among the varieties N. P. 4, 12, 52, 165, C. 518, except N. P. 12, all exhibited their maximum germination in the acid medium, pH4 being the most suitable reaction for the purpose of obtaining good germination in N. P. 52, N. P. 165 and C. 518, whereas N. P. 4 gave the best performance in pH5 ; N.P. 12, on the other hand, thrived best under alkaline medium pH9. N. P. 52 showed outstandingly, higher germination than other varieties tried, its germination percentage being from 89·7 per cent in pH10 to 96·5 per cent in pH4. N. P. 12 was worst in its germination response to the varying media except under pH9 where it gave higher germination percentage than N. P. 4, 165, and C. 528 (Table I).

TABLE I

Effect of varying H-ion concentrations on germination percentage of wheat grains

Wheat seed	pH4	pH5	pH6	pH7	pH8	pH9	pH10	Critical difference
N. P. 165	87·00	82·00	84·00	78·00	73·00	72·00	70·00	16·17
N. P. 52	96·50	95·70	93·70	96·05	94·00	91·70	89·70	8·78
N. P. 12	74·00	73·50	74·00	71·50	71·00	81·50	72·00	10·92
N. P. 4	85·00	88·00	76·00	80·00	76·50	72·50	72·00	12·39
C.518	90·00	85·00	80·00	83·00	77·00	79·00	76·00	11·55

Barley. Varieties employed have been B. 16, C. 51, T. 41. The varieties B. 16 C. 51 showed similar trend, in that they gave the least germination in *p*H6, followed by a rise at *p*H7, but the variety T. 41 showed the lowest germination in *p*H10 and highest in *p*H4 (Table II)

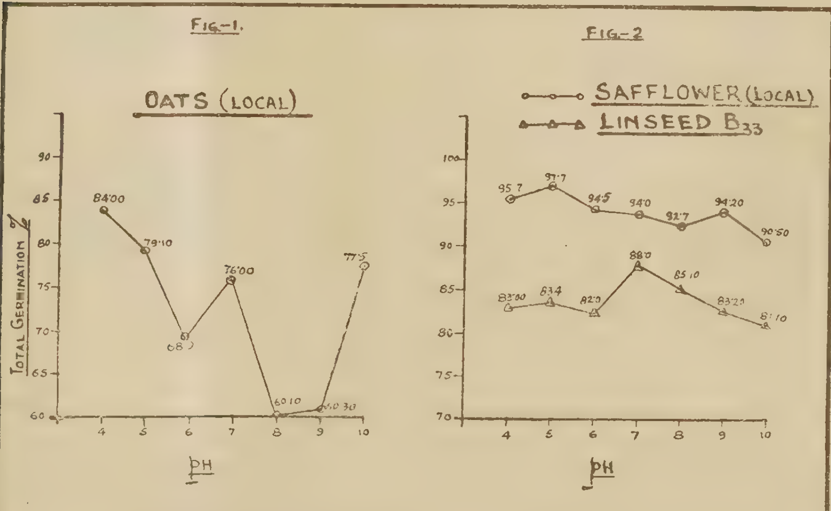
TABLE II

Effect of varying H-ion concentrations on germination percentage of barley

Barley seeds	*p*H4	*p*H5	*p*H6	*p*H7	*p*H8	*p*H9	*p*H10	Critical difference
B. 16	94·40	90·70	85·50	94·90	93·70	91·30	90·40	5·67
T. 41	84·00	82·50	81·00	82·00	80·50	80·00	78·00	10·08
C. 51	95·50	97·00	87·00	92·50	90·00	88·00	87·50	4·62

Oats (*local*). Best germination was observed in *p*H4, which gave significantly superior germination percentage over those attained in *p*H6, *p*H8, *p*H9, whereas increases in germination percentages in *p*H5, *p*H7 and *p*H10 are statistically significant to germination percentages attained in *p*H8 and *p*H9. Here three maxima have been recorded at *p*H4, *p*H7 and *p*H10 (Fig. 1).

Oilseeds. The oilseeds (safflower, linseed) show a great fluctuation in their germination percentage in the varying media. Safflower shows a liking for acidic medium to reach the highest germination percentage, while linseed does so in the neutral solution (Fig. 2).



RELATION BETWEEN GERMINATION & PH

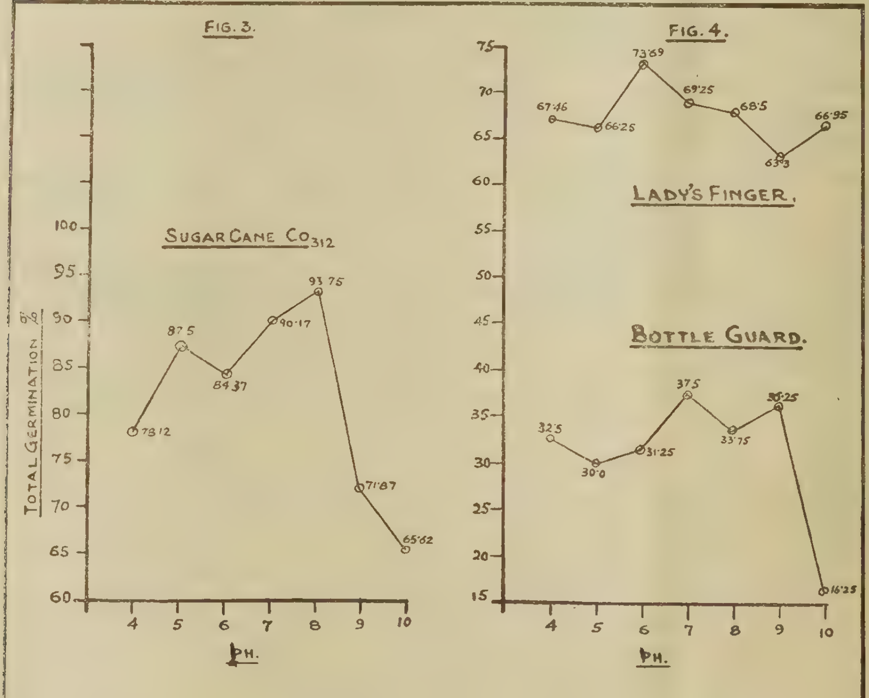
Safflower. The best germination energy is found to be displayed in the acidic medium, showing the highest germination of 97·7 per cent in *p*H5. There are two maxima found one in the acidic range at *p*H5 and the other in alkaline range at *p*H9 (Fig. 2).

Linseed B. 33. The highest germination occurred in neutral solution of *p*H7. The two maxima occur at *p*H5 and *p*H7 (Fig. 2).

Pulses. Pulses (pigeonpea, gram) prefer acidic medium for their germination, while neutral and alkaline media are not so favourable. The extreme solution of the alkaline range, *p*H10 has a harmful effect (Table III).

Paddy. Among varieties N. 22, T. 64, T. 136, the first two exhibited highest germination in *p*H8 while the last, T. 136, gave the highest germination in *p*H9. All the three varieties show two maxima, the highest peak being in the alkaline and the lower one in the acidic medium (Table III).

Sugarcane Co. 312. Its germination responses in *p*H5, *p*H7 and *p*H8 are significantly higher than in *p*H10. The germination in *p*H8 is significantly superior to that attained in *p*H9 or in *p*H10. The maxima are noticed at *p*H5 and *p*H8 (Fig. 3).



RELATION BETWEEN GERMINATION & PH

TABLE III

Effect of varying H-ion concentrations on germination percentage of pulses and paddy

Seeds	pH4	pH5	pH6	pH7	pH8	pH9	pH10	Critical difference
Pigeonpea (chocolate coloured)	93·50	94·00	90·00	92·50	91·50	91·50	88·50	4·41
Gram (local)	86·00	90·00	81·00	82·00	84·00	77·00	75·00	6·42
Paddy N. 22	94·50	95·00	94·00	95·00	97·50	93·50	91·50	4·42
Paddy T. 64	76·00	76·00	80·00	71·00	89·00	83·00	81·00	12·30
Paddy T. 136	84·50	86·50	85·00	83·00	87·50	88·00	85·50	12·18

Vegetable seeds. The seeds differed in their response to the varying media (Fig. 4). *Bottle-gourd* preferred neutral solution and pH9 for giving good germination but the increases in germination percentages in these pH values over the others are statistically insignificant.

Lady's finger. It can tolerate to a fair extent the solutions of different pH used in this investigation, but the most suitable is that at pH6 which gives significantly higher germination compared to that attained in pH9, which is lowest.

SUMMARY

The present investigation is an attempt to study the tolerance of different crop and vegetable seeds to solutions of varying H-ion concentrations. Seeds of different crops have been germinated in solutions ranging from pH4 to pH10.

Germination counts were recorded after every twelve hours, till no further seeds germinated.

Two maxima of germination have been noticed in all cases, except in oats, where three maxima have been observed.

Maximum germination of the seeds of wheat, barley, oats, pulses, safflower occurred in solutions of pH4 and pH5, while linseed, bottle-gourd seeds attained greatest germination in pH7 and lady's finger in pH6, whereas paddy and sugarcane (sets) gave optimum germination in pH8.

A reaction of pH10 exerts a depressing effect on the germination of all seeds except those of oats and lady's finger.

REFERENCES

Arrhenius, O., (1922). H-ion conc., soil properties and growth of higher plants. *Arch. Bot.*, **18**, 1-54

Bryan, O. C., (1923). *Soil Sci.*, **15**, 375

Hoagland, D. R., (1919). *J. agric. Res.*, 18, 73-117

———— (1923). *Cal. Agric. Exp Stu. Tech.*, Paper 12

REFFERENCES—*contd.*

Hoagland, D. R. (1926). *Sci. Agric.*, **6**, 141-151 ; 177-189

Singh, B. N., Chakravarti, S. C. and Rao, Y. V., (1935). The influence of steeping in sols. of varying H-ion concs. on the germination early growth of canes. *Indian J. agric. Sci.*, **5**, 715

Singh, B. N. and Mitra, G. P., (1937). Plant growth in relation to H-ion changes in its medium. *Indian J. agric. Sci.*, **8**, 327

THE EFFECT OF CERTAIN SOIL FACTORS ON THE YIELD OF MAJOR CROPS IN THE PUNJAB

III GRAM

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(With ten text-figures)

IN the two previous papers Hoon, Dhawan and Madan [1941, 1946] investigated the effect of different soil factors on the yield of wheat and rice. The first paper [1941] brought out significant correlation between the manganese and available phosphate contents of soils of wheat areas in different districts of the Punjab and the yeild of wheat. In the second paper [1946], it was found that the soil characteristics which manifested significant correlations with the yield of rice were pH, exchangeable sodium and degree of alkalisation for soils of Gujranwala District, and exchangeable calcium and sodium, degree of alkalisation and nitrogen for soils of Sheikhupura District. This prompted us to extend the investigation to the third major crop in the province *i.e.* gram.

Collection of soil samples

Fifty sampling sites were selected and yield of gram [expressed in maund (equivalent to 82 lb.)] per acre at each site during that year ascertained from the canal officers and local zamindars. The profile was exposed near the centre of each field. Two soil samples were collected one from top nine inches representing the depth mainly affected by the ploughing and the other from the next nine inchee containing the major root system of the crop. During the sampling only those fields were chosen, which were normal from the point of view of irrigation, rotation of crop, water table, etc. etc. Thus the major factors contributing towards the yield of the crop were the differences in the soil constants of these sites.

Experimental

The soils were analyzed for

(i) Total soluble salts

(ii) pH

(iii) Calcium carbonate content

(iv) Exchangeable sodium plus potassium

(v) Exchangeable calcium

(vi) Degree of alkalisation

(vii) Manganese content

(viii) Total nitrogen content

(ix) Available nitrate content

(x) Available phosphate content

The pH values were determined with the glass electrode using 1 : 5 soil water, ratio. The total soluble salts were determined by the conductivity method [Hoon, Malhotra and Jain, 1941]. The calcium carbonate content was determined according to Puri [1930]. The exchangeable bases were determined by the official method. The degree of alkalisation was calculated by the following equation :

Degree of alkalisation. Exchangeable sodium plus *Potassium* × *100 Sum of major bases present in the exchangeable complex (1933)*

The manganese content was determined by the bismuthate method [1937]. Nitrogen was determined by Kjeldahl method as modified by Bal [1925] and the nitrate was extracted by water, colour developed by phenol-di-sulphonic acid and compared colorimetrically. The nitrogen and nitrate content were expressed in milligrams per 100 gm. of soils. The available phosphate was extracted from the soils by passing carbon-di-oxide [1936] and Deniges technique as elaborated by Chapman [1932] was used to develop colour. The colorimetric comparison was done by Bolt-on and William Photo-electric Colorimeter against colours developed with phosphate solutions of known strengths.

Diagrammatic representation of analytical results

With a view to facilitate comparison, the results of the various analyses have been represented graphically. The results of the various analyses have been plotted against the yield figures separately for the top 9 inches (Figs. 1—10) and second 9 inches (Figs. 1A—10A).

Statistical treatments of analytical results

The statistical analyses resulted in a number of correlations between the different soil characteristics and the gram yield figures, which are given in Table I. Tables II and III show some of the statistical constants relating to the multiple regression of the yield figures with certain characteristics of soils (Appendix).

0 to 9″ Soil samples

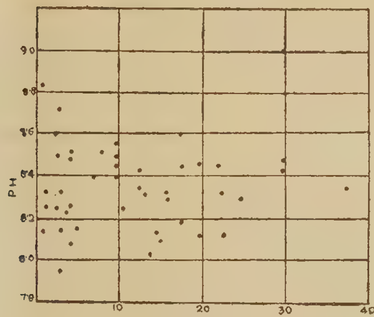


Fig. 1

Yield of gram in maunds

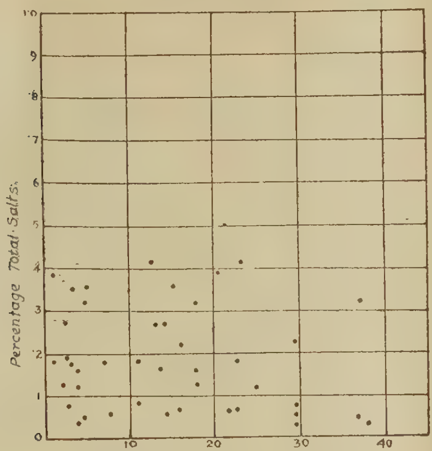
9″ to 18″ Soil samples

Fig. 1A

Yield of gram in maunds

Figs 1 and 1A—*ph* of soil in relation to yield of gram

0 to 9″ Soil samples



Yield of gram in maunds per acre

Fig. 2

9″ to 18″ Soil samples

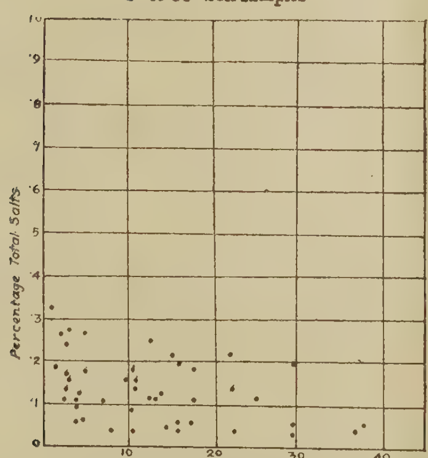


Fig. 2A

Yield of gram in maunds per acre

Figs. 2 and 2A.—Percentage of total soils in relation to yield of gram

0 to 9″ Soil samples

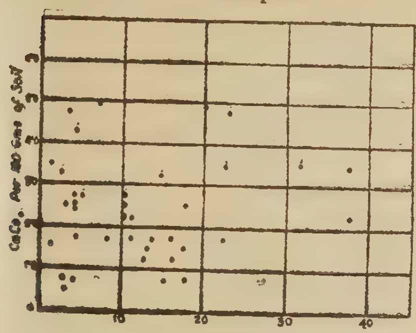


Fig. 3

9″ to 18″ Soil samples

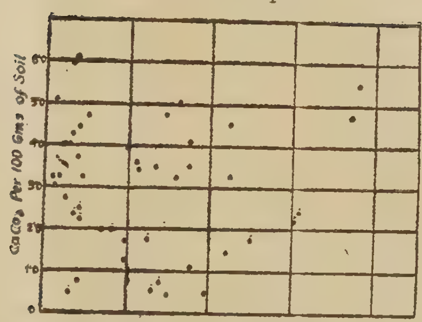


Fig. 3A

Figs. 3 and 3A.—Calcium carbonate content of soils in relation to yield of gram

0 to 9″ Soil samples

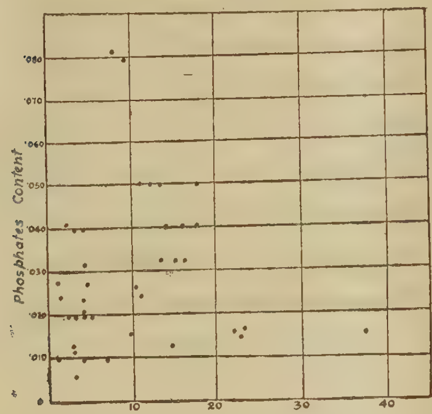


Fig. 4

Yield of gram in maunds per acre

9″ to 18″ Soil samples

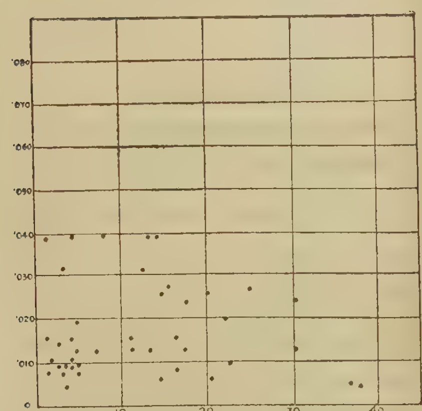
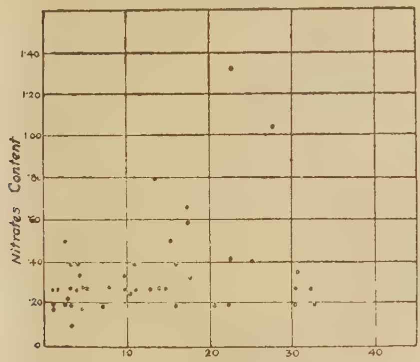


Fig. 4A

Yield of gram in maunds per acre

Figs. 4 and 4A.—Phosphates content of soil in relation to yield of gram

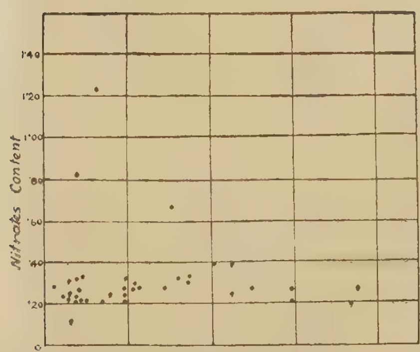
0 to 9″ Soil samples



Yield of gram in maunds per acre

Fig. 5

9″ to 18″ Soil samples



Yield of gram in maunds per acre

Fig. 5A

Figs. 5 and 5A.—Nitrates content of soil in relation to yield of gram

0 to 9″ Soil samples

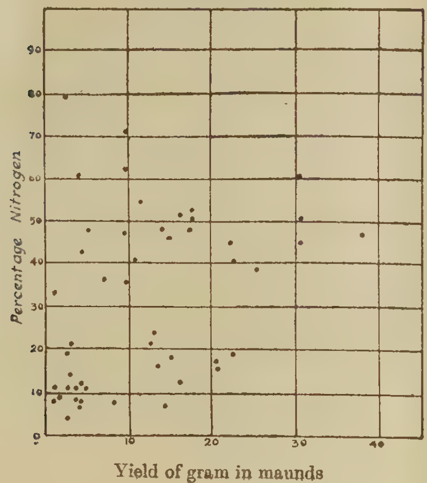


Fig. 6

9″ to 18″ Soil samples

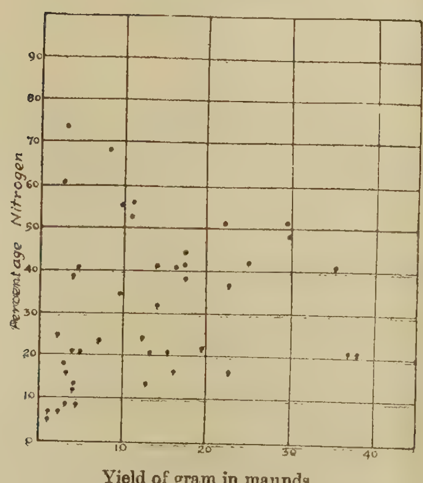
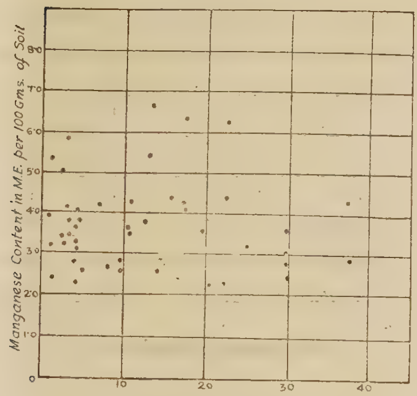


Fig. 6A

Figs. 6 and 6A.—Percentage of nitrogen content in relation to yield of gram

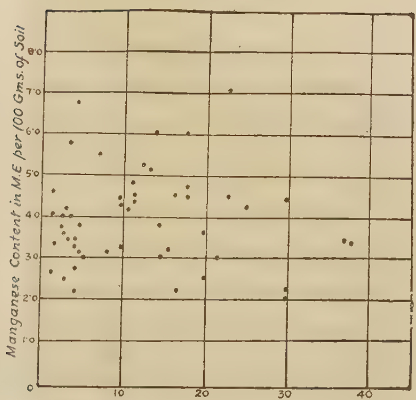
0 to 9″ Soil samples



Yield of gram in maunds per acre

Fig. 7

9″ to 18″ Soil samples

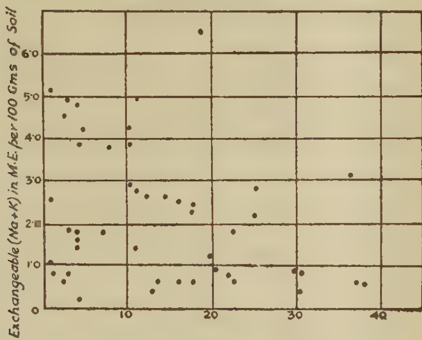


Yield of gram in maunds per acre

Fig. 7A

Figs. 7 and 7A.—Manganese content of soil in relation to yield of gram

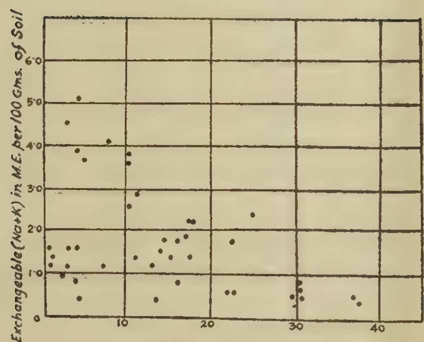
0 to 9″ Soil samples



Yield of gram in maunds per acre

Fig. 8

9″ to 18″ Soil samples



Yield of gram in maunds per acre

Fig. 8A

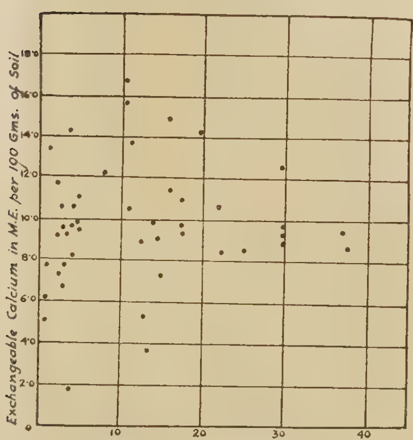
Figs. 8 and 8A.—Exchangeable sodium plus potassium content (m.e.) of soils in relation to yield of gram.

0 to 9″ Soil samples

Yield of gram in maunds per acre

Fig. 7

9″ to 18″ Soil samples

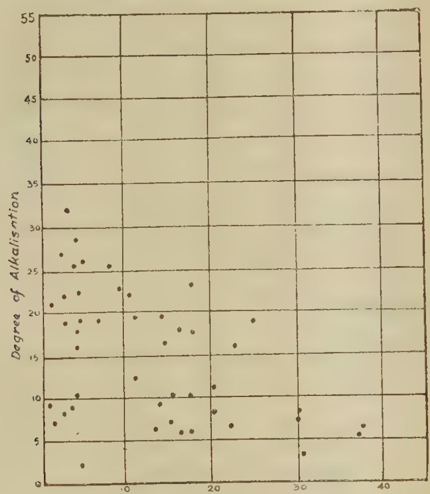


Yield of gram in maunds per acre

Fig. 7A

Figs. 9 and 9A.—Exchangeable calcium content of soil in relation to yield

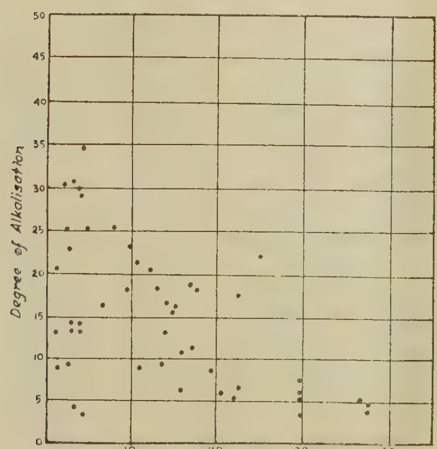
0 to 9″ Soil samples



Yield of gram in maunds

Fig. 10

9″ to 18″ Soil samples



Yield of gram in maunds

Fig. 10A

Figs. 10 and 10A.—Degree of alkalisation in relation to yield of maunds

TABLE I

Correlation of the yield of gram with certain soil characteristics of the first and second nine inches of soil samples

(Number of observations—50)

Soil characteristics	Correlation coefficient			
	Between soil characteristics 1st and 2nd 9 in.	Yield and 1st 9 in. of soil	Yield and 2nd 9 in. of soil	Multiple yield with 1st and 2nd 9 in. of soil
pH	0·663*	—0·110	—0·180	0·180
Total salt content	0·812*	—0·378*	—0·432*	0·434*
Calcium carbonate	..	—0·091	—0·160	..
Phosphate	..	—0·074	—0·044	..
Nitrate	..	—0·162	0·181	..
Total nitrogen	0·559*	0·142	0·137	0·158
Manganese	..	—0·024	—0·078	..
Exchangeable (Na + K)	0·954*	—0·466*	—0·579*	0·648*
Exchangeable (Ca)	..	0·168	0·108	..
Degree of alkalisation	0·838*	—0·500*	—0·535*	0·544*

* Indicates significance at 1 per cent level

TABLE II

Some statistical constants connected with the multiple regression of the yield of gram with total salt content and exchangeable (Na + K)

(Number of observations—50)

Statistical constant	Yield	Total salts	Na + K
Mean	12·57	0·170	1·94
Standard error of mean	1·40	0·0196	0·187
Total correlation with yield.	..	—0·418	—0·528
Multiple correlation of yield with T. S. and (Na + K)	0·661	..	..
Partial regression coefficients	..	—28·48	—3·84
Partial standard regression co-efficients	..	—0·398	—0·512
' t ' for significance of partial regression coefficients	..	—3·63*	4·67*

* Indicates significance at 1 per cent level

TABLE III

Some statistical constants connected with the multiple regression of the yield of gram with total salt content and dergee of alkalisation

(Number of observation—50)

Statistical constants	Yield	Total salt	Degree of alkalisation
Mean	12·57	0·170	16·43
Standard error of mean	1·40	0·0196	1·35
Total correlation with yield	..	—0·418	—0·541
Multiple correlation of yield with total salt content and degree of alkalisation	0·585	..	..
Partial regression coefficients	..	—17·45	—0·464
Partial standard regression coefficients	..	—0·244	—0·445
't' for significance of partial regression coefficients	..	1·90	3·46*

* Indicates significance at 1 per cent level

N.B.—The yield is measured in maunds per acre

Total salts are expressed as a percentage

(Na+K) is given in milli-equivalents per 100 gm of soil

Table I shows that (1) A soil characteristic in the top nine inches sample is positively correlated with the same characteristic of the second nine inches of the sample i.e. a high content in the top samples means a high content in the second nine inches samples and vice versa. Similar thing was noticed previously for wheat and rice areas.

(2) The only significant correlations of the yield are those with exchangeable (Na + K), degree of alkalisation and total salt content and the correlations with the second nine inch soil samples are somewhat higher than those with top nine inch samples though the differences are not statistically significant. Further, the correlations are negative indicating that a high content of these characteristics generally means a lower yield. The manganese, phosphate and nitrogen do not

seem to indicate any relation to the yield of gram. As far as this soil characteristic is concerned, there exists a very conspicuous difference in respect to its effect on the gram, rice and, wheat yields. A very significant negative [1941] correlation was found to exist between the manganese content of soils and the yield of wheat, but there was no correlation with the rice yields [1946]. Regarding phosphate, only the wheat soils exhibited a significant and positive correlation [1941]. There was no significant correlation between the nitrogen content and the yield of wheat. But the rice soils manifested a positive correlation with the nitrogen content of soils [1946].

Next, multiple correlations of yield with (i) total salts and exchangeable (Na+K) and (ii) total salts and degree of alkalisation were worked out. Some statistical constants connected with these correlations are set down in Tables II and III. In these tables, the correlations have been worked out with the average values of the soils characteristics of the top and second nine inches of samples.

Table II shows that both the partial regression coefficients of total salts and (Na + K) are significant. An increase of 0·1 in the total salts decreases the yield by 2·85 per acre, while an increase of 0·1 (Na + K) milli-equivalent per 100 gm. of soil decreases the yield by 0·38 per acre. The regression coefficients are affected by units of measurement. In order to get an idea of the relative importancel of total salts and (Na + K) in affecting the yield, the partial *standard* regression coefficients (i.e. the regression coefficients obtained by expressing the varieties in units of respective standard deviations) have also been worked out. These bring out that variations in (Na + K) are relatively more important than those of total salts on their effect on yield.

Table III shows that the multiple correlation coefficient of yield with total salts and degree of alkalisation is somewhat lower than the multiple correlation with total salt and Na + K (Table II), so that for forecasting the yield of gram the regression formula with total salt and (Na + K) is slightly better than formula with total salt and degree of alkalisation.

Conclusions

The examination of the analytical results by the method of correlational analysis on the yield of gram for the top (A) and the second (B) nine inches soil samples are summarised in tabular form below:

Soil characteristic	Remarks
Total salt content . . .	Significant for both A and B
Exchangeable (Na +K) . .	Significant for both A and B
Degree of alkalisation . . .	Significant for both A and B

Summary

The top and second nine inches soil samples from gram areas in the Punjab have been analyzed and the results of the analyses employed for determining the statistical correlations with the figures for yield of gram at those sites. It has been shown that a significant and negative correlation exists between the total salts, exchangeable (Na + K) and degree of alkalisation and the yield.

The other soil characteristics seem to affect the yield of gram partially.

REFERENCES

Bal, D. V. (1925). The determination of nitrogen in heavy clay soils. *J. agric, Sci.* **15**, 454

Chapman, H. D. (1932). Studies on the blue colorimetric method for the determination of phosphorus. *Soil Sci.* **33**, 125

Hoon, R. C., Dhawan, C. L. and Madan M. L. (1941). The effect of certain soil factors on the yield of wheat in the Punjab. *Soil Sci.*, **51**, 339

Hoon, R. C., Dhawan, C. L. and Madan, M. L. (1946). The effect of certain soil factors on the yield of major crops in the Punjab II Rice. *Indian J. agric. Sci.*, XVI, (IV)

Hoon, R. C., Malhotra, J. K., Jain, L. C. (1941). The conductometric method of determining the soluble salt content of soils for use in soil survey work. *J. Ind. Chem. Sci.* XVIII, **2**, 103

Imperial Bureau of Soil Science, Bull. (1937). **17**, 4

Puri, A. N. (1930). A new method of estimating total carbonates in soil. *Men. Dept. Agric. India (Pusa) Series. Bull.* 206

——— (1933). The relation between the exchangeable sodium and crop yield in Punjab soils and a new method of characterising alkali soils. *Punj. Irri. Res. Inst. Res. Bull.* IV,5

——— and Asghar, A. G. (1936). Estimation of available phosphate in soils by CO2 extraction. *Soil Sci.*, **42**, 39

APPENDIX

Correlation between the yield of gram and certain soil characteristics

Serial number	Yield in maunds	pH		Total salts		Ca Co3		Exchangeable Na+K		Exchangeable Ca		Phosphates		Nitrates		Nitrogen		Manganese		Degree of alkalisation $=\frac{Na+K}{Na+K+Ca}\times 100$	
		I ft.	II ft.	I ft.	II ft.	I ft.	II ft.	I ft.	II ft.	I ft.	II ft.	I ft.	II ft.	I ft.	II ft.	I ft.	II ft.	I ft.	II ft.	I ft.	II ft.
1	10	8·40	8·30	·05	·09	2·50	4·00	3·8	3·6	17·5	15·7	·016	.007	·27	·33	47·6	77·0	2·7	4·3	17·84	18·65
2	10	8·55	8·90	·11	·16	2·25	1·25	4·2	3·8	11·3	16·7	·016	·024	·33	·20	36·4	11·2	3·6	4·4	27·10	18·54
3	5	8·15	8·20	·36	·18	2·75	4·75	4·2	3·7	11·9	11·1	·020	·008	·27	·20	49·0	25·6	2·7	3·1	26·09	25·00
4	16	8·30	8·48	·07	·05	1·25	5·00	2·5	1·8	11·3	14·9	·040	·008	·20	·20	12·6	16·8	2·5	2·4	18·12	10·78
5	8	8·52	8·38	·06	·04	1·75	2·00	3·8	4·1	10·9	12·1	·080	·040	·27	·25	8·4	68·6	2·8	3·3	25·85	25·31
6	10	8·50	8·40	·04	·04	1·00	0·75	2·9	3·0	9·9	9·9	·080	·080	·25	·27	71·4	56·0	3·0	3·4	22.66	23·26
7	2·5	8·50	8·62	·20	·24	3·25	4·00	4·5	5·1	12·1	11·7	·020	·015	·50	·22	79·8	60·2	3·4	3·6	27·11	30·36
8	4	8·51	8·40	·04	·06	2·50	3·75	4·8	5·1	11·9	9·5	·020	·016	·20	·33	60·2	39·2	2·9	3·3	28·74	34·93
9	10	8·45	8·42	·13	·18	2·75	1·75	2·8	2·6	9·7	13·7	·026	·053	·40	·25	63·0	35·0	3·7	4·6	22·40	15·95
10	3	8·72	8·50	·08	·28	4·75	4·25	4·9	4·7	10·1	10·5	·005	·005	·20	·25	93·8	74·2	3·5	4·0	32·67	30·92
11	1	8·84	9·16	·38	·50	3·50	3·25	5·1	4·8	4·7	5·1	·010	·010	·27	·2	33 6	10·36	3·9	4·1	52·04	48·48
12	4·5	8·20	8·45	·05	·06	1·75	3·25	3·8	3·9	12·9	9·5	·027	·013	·18	·33	43·4	40·6	3·9	3·2	22·75	29·10
13	11	8·25	8·24	·08	·15	2·25	3·50	2·7	2·9	10·7	10·5	·024	·013	·40	·27	54·6	53·2	1·8	4·5	20·15	21·64
14	14	8·03	3·14	·27	·13	1·00	0·75	2·0	1·5	8·1	9·9	·040	·040	·27	·20	48·5	41·2	2·7	4·0	19·80	13·16
15	14·5	8·14	8·03	·06	·05	3.25	4·75	2·6	1·8	12·9	8·9	·013	·006	·27	·27	7·0	32·2	3·0	3·1	16·77	16·82
16	30	8·22	8·15	·03	·03	0·75	0·25	0·9	0·8	9·7	9·6	·027	·024	·27	1·00	11·2	15·4	3·7	4·6	8·49	7·69
17	37	8·00	7·98	·05	·04	3·50	4·75	0·6	0·5	9·8	9·4	·010	·004	·27	·20	9·8	21·0	4·4	3·6	5·77	5·05
18	37·5	8·35	8·52	·04	·05	2·25	5·50	0·6	0·4	8·0	8·6	·016	·004	·20	·27	47·6	21·0	3·0	3·6	6·98	4·44
19	30	8·42	8·49	·06	·06	2·00	2·00	0·8	0·6	9·4	9·2	·027	·018	·20	·20	50·4	11·2	3·1	2·2	7·84	6·12
20	20	8·46	8·45	·05	·06	5·00	4·00	0·9	1·0	9·6	10·0	·006	·006	·20	·20	15·4	22·7	2·3	2·7	8·57	9·09
21	22	8·46	8·46	0·7	·21	1·75	1·50	0·75	0·6	10·6	10·6	·016	·020	·20	·20	45·4	50·2	2·3	3·1	6·58	5·36
22	30	8·48	8·60	·23	·20	2·50	2·25	0·4	0·5	10·8	8·9	·016	·013	·20	·20	60·5	48·4	2·8	2·4	3·57	5·32
23	30	8·42	8·52	·08	·06	1·00	2·50	0·4	0·5	10·8	12·5	·013	·032	·27	·27	45·2	50·4	2·6	2·4	3·57	3·85
24	4·5	8·08	8·35	·32	·27	2·00	2·50	0·2	0·4	7·5	9·9	·032	·020	·27	·20	10·5	8·5	4·0	3·9	2·60	3·88
25	2·5	8·25	8·38	·27	·27	0·75	2·75	0·6	1·0	6·1	9·1	·040	·015	·20	·20	4·5	7·6	3·3	4·0	8·96	9·90

APPENDIX—*contd.*

Correlation between the yield of gram and certain soil characteristics—contd.

Serial number	Yield in maunds	pH		Total salts		Ca Co3		Exchangeable Na+K		Exchangeable Ca		Phosphates		Nitrates		Nitrogen		Manganese		Degree of alkalisation $= \frac{Na+K}{Na+K+Ca} \times 100$	
		I ft.	II ft.	I ft.	II ft	I ft.	II ft.	I ft.	II ft.	I ft.	II ft.	I ft.	II ft.	I ft.	II ft.	I ft.	II ft.	I ft.	II ft.	I ft.	II ft.
26	1	8·33	8·33	·18	·16	2·00	3·00	1·0	1·2	9·9	7·7	·020	·016	·20	·20	8·2	5·4	3·2	2·8	9·17	13·48
27	2·5	8·30	8·42	·12	·11	1·00	1·75	2·2	2·4	9·5	8·5	·040	·027	·40	·27	39·5	42·7	3·3	4·4	18·80	22·02
28	1	8·14	8·15	·74	·33	2·00	5·00	2·6	1·6	9·5	6·1	·027	·040	·18	·20	10·4	6·8	5·4	4·7	21·48	20·78
29	3	8·15	8·30	·35	·16	3·00	6·00	1·9	1·6	7·9	9·5	·013	·010	·27	Trace	10·3	9·7	3·8	4·2	19·39	14·41
30	12·5	8·43	8·41	·41	·11	1·25	1·75	2·5	2·0	5·7	7·9	·050	·032	Trace	·60	21·3	24·7	3·9	5·4	31·33	20·20
31	13·5	8·32	8·53	·16	·12	1·75	3·50	0·6	0·4	5·7	3·7	·032	·013	·80	·80	16·3	21·2	6·7	6·1	9·52	9·76
32	4	8·48	8·80	1·00	·65	0·75	0·75	1·8	2·0	5·3	1·9	·040	·040	·40	·80	8·7	10·2	1·4	6·9	25·35	51·28
33	13	8·35	8·22	·27	·25	1·50	0.50	0·4	1·2	5·7	5·3	·050	·040	·27	·08	25·4	14·3	5·5	5·3	6·56	18·46
34	3	8·33	8·45	·18	·14	2·50	6·00	1·8	2·0	7·5	6·7	·020	·008	·10	·10	14·3	16·2	4·2	3·5	19·35	22·99
35	4	8·20	8·15	·16	·12	4·25	4·25	1·6	0·8	8·3	8·1	·010	·010	·20	·27	11·8	13·2	3·3	2·9	16·16	8·99
36	4	8·22	8·43	·12	·10	2·25	4.50	1·8	1·6	8·2	9·6	·024	·010	·33	·20	7·8	0·3	3·2	2·3	18·00	14·29
37	1·25	8·25	8·45	·30	·19	1·50	3·25	0·8	1·4	9·8	13·4	·024	00·8	·27	·26	8·6	12·4	2·5	3·4	7·55	9·46
38	20	8·12	8·04	·05	·04	0·50	0·50	1·2	1·0	9·2	14·2	·032	·026	·40	·40	17·8	22·4	3·7	3·8	11·54	6·58
39	15	8·10	8·14	·36	·21	0·75	0·50	0·6	1·4	7·8	7·2	·032	·026	·50	·66	18·7	21·6	2·8	3·3	7·14	16·28
40	4	8·25	8·28	·16	·11	2·75	4·50	1·4	1·6	12·2	12.6	·020	·0099	·27	·20	10·8	12·3	3·7	3·5	10·29	13·11
41	11	8·23	8·35	·18	·14	1·75	3·60	1·4	1·4	9·6	13·8	·050	·016	·27	·27	40·5	56·3	4·4	5·0	12·73	9·21
42	7	8·40	8·35	·18	·10	5·00	2·00	1·8	1·2	7·4	6.0	·010	·013	·20	·20	37·2	24·5	4·3	5.7	19·57	16·67
43	2·5	8·60	8·45	·13	·11	3·25	4·00	2·8	2·4	9·6	7·2	·011	·0099	·20	·20	19·3	25·2	5·0	3·8	22·58	25·00
44	22·5	8·32	8·10	·18	·14	4·75	4·50	1·8	1·8	9·4	8·4	·016	·010	·40	·25	19·4	16·8	4·5	4·6	16·07	17·65
45	22·5	8·12	8·24	·07	·04	3·50	3·25	0·6	0·6	11·4	8·0	·015	·010	1·33	·40	40·4	37·6	6·3	7·1	5·00	6·98
46	16	8·32	8·28	·22	·09	1·75	3·25	0·6	0·8	9·4	11·4	·032	·016	·40	·33	51·4	40·3	4·5	4·7	6·00	6·56
47	17·5	8·08	8·18	·32	·18	0·75	1·00	0·6	1·4	9·0	11·0	·040	·024	·60	·31	52·1	38·5	6·4	6·1	6·25	12·29
48	17·5	8·60	8·65	·16	·06	2·50	4·00	2·2	2·2	10·2	9.6	·040	·013	·66	·33	48·7	44·2	4·2	4·7	17·74	18·64
49	17·5	8·45	8·25	·12	·11	1·50	3·50	2·4	2.2	8·0	9·4	·050	·013	·33	·30	50·8	41·4	4·3	4·8	23·08	18·97
50	3	7·95	8·40	·19	·17	0·50	0·50	0·8	1·2	8·0	7·8	·040	·03	0·40	·31	20·4	19·8	5·9	5·9	9·09	13 33

ALBUMIN AND GLOBULIN FROM THE SEED CAKES OF CARILLA FRUIT

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SUN-DRIED, powdered seeds of carilla fruit (*Momordica charantia, N. O. Cucurbitaceae*) were first extracted with petroleum ether for the fatty oil, and then subsequently with benzene, chloroform and alcohol. Thus freed from all fatty and alcohol-soluble matter, the seed-cakes were further powdered to pass through 0·5 mm. mesh.

The carilla fruit is edible, and along with its seeds, it is boiled in certain preparations. And since the seeds appear to contain sulphur containing proteins a study of the seed-cakes was considered of interest.

Cystine was estimated [Airan and Ghatge, 1950] separately according to the method of Callan and Toennies [1941] and methionine according to that of Horn Jones and Blum [1946]. The results reported were cystine 1·37 per cent and methionine 1·529 per cent.

In the present investigation, since only albumin and globulin were obtained in any appreciable quantity, nitrogen distribution in these alone was studied according to the method of van Slyke [1911] as later modified by Plimmer and Rosedale [1925] and Cavett [1932].

Experimental

A test portion was boiled with distilled water, and rapidly filtered hot. The filtrate was boiled and allowed to cool. On cooling, a white solid separated, which was filtered and finally dried by washing with absolute alcohol and dry ether. It had now become insoluble in water, and gave on analysis the following results :

C, 46·3 ; H, 7·2 ; N, 14·5 ; S, 0·967 ; ash, 1·1 per cent.

This indicated that it was a water soluble protein, now denatured. Hence, following the method of Basu, *et al.* [1937] *a* systematic attempt was made for the isolation of proteins soluble in different solvents like water, sodium chloride solution, dilute alcohol and dilute alkali solution.

16·3 gm. of the powdered seed-cakes were shaken in a mechanical shaker with two successive lots of 150 c.c. of cold distilled water, the continuous shaking in each case lasting for two hours since this was found enough to extract the soluble protein. The aqueous extracts were combined and kept (with a couple of drops of toluene) in an ice chest over night, when a solid separated out. It weighed one gm. After its separation, neither heating nor the addition of a cold saturated solution of ammonium sulphate threw out any more solid. The albumin so obtained was finally dried with absolute alcohol and dry ether.

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The residual seed-cakes were subsequently treated in similar manner with 2 per cent sodium chloride solution, 50 per cent alcohol and finally with 0·2 per cent sodium hydroxide solution. The choice of 50 per cent alcohol was made in accordance with the findings of Hoagland [1911]. The globulin extracted by sodium chloride was purified by dialysis, and finally dried by washing with absolute alcohol and dry ether.

The amounts of proteins obtained from various solvents are given in Table I, and the distribution of nitrogen in albumin and globulin in their diamino and monoamino fractions in Table II.

TABLE I

Protein recovered

Solvent	Weight gm.	Percentage	Remarks
Water	1·0	6·12	Albumin
2 per cent NaCl	0·99	6·07	Globulin
50 per cent alcohol	Practically *nil*	*Nil*	..
0·2 per cent NaOH	0·2	1·22	Glutelin
Total	2·19	13·41	..

TABLE II

Distribution of nitrogen in albumin and globulin in their diamino and monoamino fractions

—	Percentage of total nitrogen	
	Albumin	Globulin
Amide N	2·35	3·887
Humin N	0·07	0·06
Diamino fraction :		
Arginin N	50·55	49·933
Histidine N	15·76	14·453
Cystine N	1·07	1·400
Lysine N	19·92	21·93
Monoamino fraction :		
Amino N	7·5	7·2
Non amino N	3·89	3·17
Total	101·11	100·033

Summary

Albumin and globulin from fat free seeds of carilla fruit have been analyzed for their sulphur containing amino-acids and for the distribution of nitrogen in them according to the van Slyke method. The seed cakes contain 6·12 per cent albumin and 6·07 per cent globulin.

REFERENCES

Airan, J W. and Ghatge, N. D. (1950). *J. Indian chem. Soc.*, **27**, 99

Basu, *et al.* (1937). *Indian J. med. Res.* **24**, 1027

Callen, T. P. and Toennies, G. (1941). *Indian* and *Eng. chem. Anal Ed.* **13**, 450

Cavett, J. W. (1932). *J. biol. Chem.*, **95**, 335

Hoagland (1911). *Ind.* and *Eng., Chem.* **3**, 838

Horn, M. J., Jones, D. B. ; Blum, A. E. (1946). *J. biol. Chem.*, **166**, 313

Plimmer, R. H. A. and Rosedale, J. L. (1925). *Bio. chem. J.* **19**, 1015

Van Slyke, D. D. (1911). *J. biol. Chem.*, **9**, 185

PRELIMINARY OBSERVATIONS ON THE EFFICACY OF METHYL BROMIDE AS A FUMIGANT FOR APPLES AND AGAINST SOME PESTS OF DRIED FRUITS

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(With one text-figure)

THE codling moth (*Carpocapsa pomonella* Linn.) is a serious pest of apples, pears and quinces. The presence of this in Baluchistan, North Western Frontier Provinces and Afghanistan has already been noted. In this country also there are large fruit growing areas in Kashmir and the United Provinces, and unless effective control measures are soon devised to subjugate the pest it is bound to become a menace to our infant horticultural industry. Methyl bromide has established its superiority over some of the other common fumigants in some respects or other. In other countries specially in the United States and Canada, methyl bromide is being used in fumigating fresh and dried fruits, vegetables, food grains, etc. In India this fumigant has not been used so far and the work was undertaken to find out its scope of application as a fumigant under conditions prevailing in this country.

As a result of fumigation of apples with methyl bromide there is a possibility of apple injury as observed by different workers. Phillips, Monro and Allan [1938] carried on a fundamental study of methyl bromide, fumigation on apples with respect to their maturity at the time of picking, storage conditions before and after fumigation, etc., etc. Subsequently, Phillips and Monro [1939], Chapman [1940] and Isaac [1944] working with different varieties of apples under different temperatures with different dosages of methyl bromide found apple injury to be generally associated with high dosage and longer exposure periods, and the different varieties of apples showed different degrees of tolerance to methyl bromide fumigation. Mackie and Carter [1939] reported a complete kill of codling moth larvae in pears with a dosage of ½ lb./1,000 c.ft. of space of methyl bromide for two hours at 88°F. In the case of dried fruits and grains Mackie [1938] stated that a dosage of 1 lb. 1,000 c.ft. of dried fruits, applied in gas tight tents for 12 hours or over was found to be effective against a number of pests such as *Tribolium*, *Oryzaephilus*, etc. Monro and Delisle [1945] recommended a dosage of 1·5 lb./1,000 c.ft. of methyl bromide for 16-24 hours at 60°F. and above in commodity as well as free space for steel freight cars of air-tight construction against *Tribolium castaneum* Hbst., *Oryzaephilus surinamensis* L. etc. in imported peanuts.

In the present work two aspects of the problems of fumigation of fruits with methyl bromide have been studied with the modified apparatus :

(i) tolerance of some of the varieties of apples which are grown in this country and in areas bordering this country.

(ii) toxicity to some pests of dried fruits.

Material and methods

A limited supply of two varieties of apples, e.g., Kalu and Kandahari taken at random from consignments ready for market was obtained from Baluchistan. Another batch of Kashmiri apples was purchased locally. In addition to this, hibernating larvae (in silk lining) of codling moth were obtained from Baluchistan. As regards the pests of dry fruits a constant supply of *O. surinamensis* and *T. castaneum* which are also the pests of stored products in general was available from the cultures maintained in the Entomological laboratory of the Indian Agricultural Research Institute.

Nature of fumigation apparatus employed. The apparatus used was almost the same as that used by Dudley *et al.* [1940] with some modifications. The fumigation chamber (*Fig. 1) consists of a 50 gallon ordinary petrol drum. One end of it is removed and replaced by a second one of galvanised sheet. The upper one-third is jacketted with galvanised sheet for water seal. The lid lightly fits in this jacket containing water to make the whole drum air-tight. Towards the bottom of the drum there are two holes, one of which is used for a thermometer and electric wires for an electric lamp kept inside. Through the other one is inserted a capillary glass tube for sampling and wires for an electric fan placed inside. The capillary tube enters the wire gauze tray kept on an iron stand containing the fumigating materials and samples of the air-fumigant mixture which is actually in contact with the materials are thus taken. The bulb of the thermometer is also projected upto that place to observe the variations in temperature from time to time and control it as far as possible. The fan is placed in such a position as to give a whirling motion to the inside atmosphere to secure uniformity in composition. The lid is provided with three holes. One of these is used for introducing the fumigant through a glass tube which goes upto the front of the fan so that the incoming fumigant may be immediately swept away producing a uniform mixture within a very short time. The second hole is connected with a water manometer to observe the pressure inside during fumigation and also during partial evacuation of the drum before introducing the fumigant. The third and the central hole is covered with a glass plate sealed with plasticine to see and note from time to time the temperature, humidity or any irregularity during fumigation. The holes are closed with India rubber corks, through which pass the thermometer, capillary tube, etc. One paper hygrometer which is often checked with a wet and dry bulb thermometer is kept inside along with a maximum-minimum thermometer during fumigation.

Method of introducing the fumigant.† Methyl bromide was supplied in one gallon cylinder by the National Fire Protection Co., Ltd., Surrey. At the time of the experiments it could not be filled in small glass ampoules, and was so taken from the cylinder to the fumigation chamber as a gas through a measuring arrangement. After driving out the air occupying the tubes it was collected in a graduated glass

* The Fig. shows a general arrangement of the different parts and is not strictly to the scale.

† The fumigant has been used in the form of liquid in Dudley's method. The arrangements to take occasional samples, to introduce methyl bromide in gaseous form, to note the temperature, the relative humidity and the changes in pressure inside the drum during fumigation are the differences in the method and apparatus used by Dudley and those by the present author.

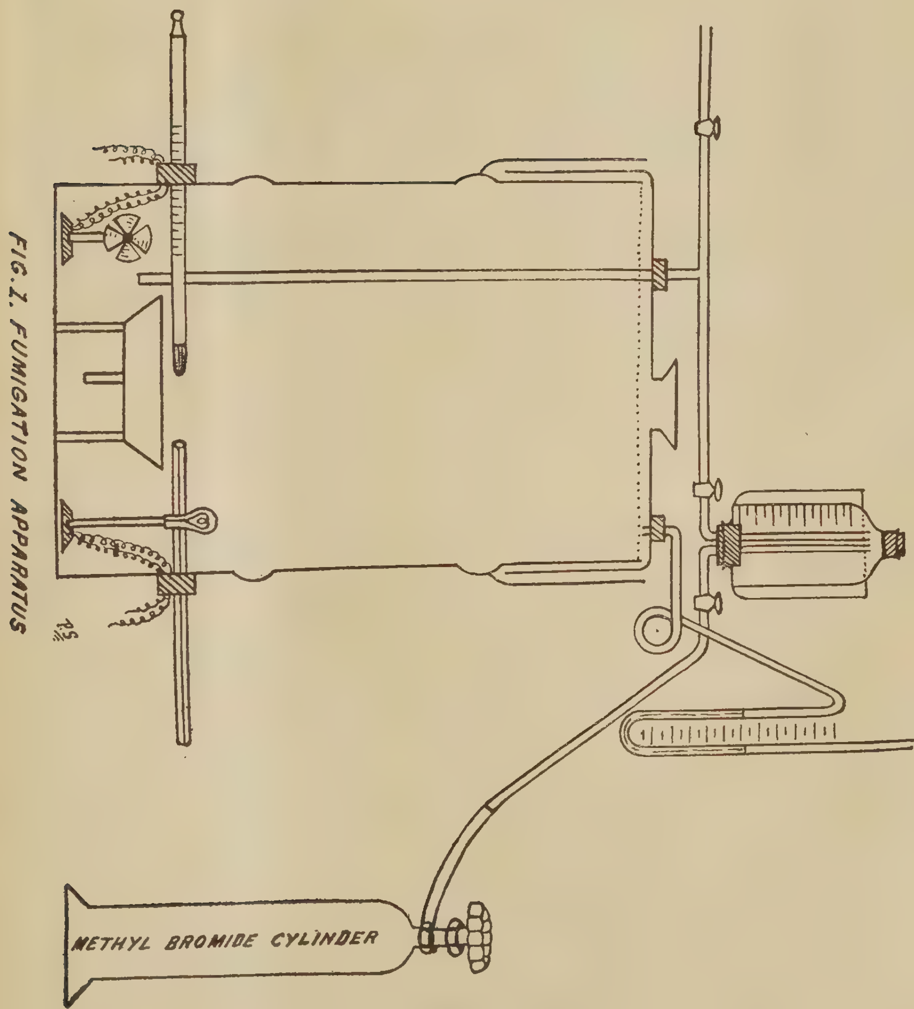

Fig. 1. Fumigation apparatus.

bell-jar inverted over water and from there the calculated amount of the gas was introduced into the partially evacuated chamber. The capacity of the chamber was 7·9 c. ft.

Analysis of the gas sample. Method used by Lewis [1945] has been followed. Gas samples are taken in evacuated bottles fitted with ground glass heads fitted with stop-cocks, joints being lubricated with the minimum amount of grease. 5 ml. of Na-methoxide in methyl alcohol taken in a sealed glass ampoule is kept inside the bottle. The bottle is evacuated to 1-3 cm. of mercury. It is then connected with the capillary glass tube end to end with a rubber tubing so that methyl bromide gets a minimum contact with rubber. The stop-cock is opened and left for 10 minutes or more to ensure complete filling of the bottle. It is then taken out, cooled and the ampoule broken by shaking. The bottle is then rotated so that the reagent may smear the sides and react with methyl bromide. It is then left for more than eight hours. The sides are then washed with about 50 ml. of distilled water. The solution is neutralized with 5 N acetic acid with phenolphthalein as indicator. An excess acid is then added to make the solution approximately O.IN with respect to acetic acid. The bromide is then determined by titration with O.OIN $AgNO_3$ using 0·1 per cent eosin as indicator.

Blank titration with 5 ml. Na methoxide and following the procedure as in actual sampling, was done. No difference in titre was noticed.

Experiments and observations

About a dozen apples or some insects with some nuts in wire gauze test tubes as the case might be, were kept in the tray inside the fumigation chamber. A maximum-minimum thermometer and a paper hygrometer were also placed in it. The lid was then placed in position and the manometer and the glass bell jar were connected. Another maximum-minimum thermometer was also kept outside. The chamber was then connected with a filter pump and the fan started. The pressure was brought to 4 in. (water) less than the atmospheric pressure. After 15 minutes of the running of the fan, the fumigant was allowed in, and the chamber was then brought to atmospheric pressure by allowing the atmospheric air to come in. Within 5 to 10 minutes a gas sample was taken through the capillary tube in the vacuum bottle and analyzed. Another sample was also taken 10 to 15 minutes before the completion of fumigation. In fumigation experiments with apples concentration of fumigant inside the chamber was not analyzed. It was found to be almost the same as the theoretically one (*vide* Table I, 1 lb./1,000 c.ft.=16 mg./L.). From time to time the relative humidity and temperature inside were noted. The temperature was generally kept at the atmospheric one and any rise of temperature was controlled by spreading water on the sides of the chamber. At the end of the desired exposure the materials were taken out. In the case of fruits, these were left exposed to the atmosphere for days together, and day to day observations were made to compare with those of the unfumigated ones. The work was undertaken to find out the suitability of methyl bromide fumigation at Quetta from where consignments of imported as well as local apples used to be sent to different markets

in India. A time limit of 15 days was taken for tests as it was assumed that within this time apples could reach the traders where better preservation arrangements could be made. In the case of insects they were taken out of the wire gauze-test tubes and kept in petri-dishes and left to the atmospheric condition for further observations. Mortality was generally counted after 24 to 72 hours.

Preliminary experiments were carried out to see the sorption and leakage of the chamber. In actual fumigation experiments, the samples taken in the beginning and at the end showed that there were very little changes in concentration during the exposure period of one to two hours, as shown in Table I.

TABLE I

Change in methyl bromide concentration in the fumigation chamber at different intervals during fumigation

Original concentration mg./L.	Final concentration mg./L.	Interval Hours min.	Change of concentration mg./L.
16·4	16·3	0—20	—0·1
16·1	16·3	0—40	+ 0·2
15·9	15·7	0—40	—0·2
17·8	17·7	0—40	—0·1
20·0	20·2	1—0	+ 0·2
20·8	21·3	2—0	- 0·5
29·3	29·8	3—20	+0·5
29·8	27·7	21—10	—2·1

An attempt was made to carry out some experiments at 45, 50 and 60 per cent relative humidity. In those experiments there was no water in the jacket and the lid was sealed to the drum with plasticine. In all the experiments having water seal, the humidity used to rise rapidly and was between 80 to 100 per cent during the fumigation period.

TABLE II

Effect of methyl bromide fumigation on apples

Varieties of apples	Dosage lb./1,000 c.ft.	Exposure hours	Temperature of fumigation °F	Injury, or effect within 15 days of experiment
1. Kulu and Kandahari	1	4	90-90·5	No change
2. Kulu and Kandahari	2	1	83-91	Negligible or no change
3. Kulu and Kandahari	2	1	81-89	No change
4. Kulu and Kandahari	2	2	88·2-96	Rotting
5. Kulu and Kandahari	2	3	86·2-94·2	Rotting
6. Kulu and Kandahari	2	4	83-91·8	Rotting
7. Kulu and Kandahari	2	4	90-97	Rotting
8. Kulu and Kandahari	3	1	87-91	No change
9. Kulu and Kandahari	3	2	86·8-100·5	Rotting
10. Kulu and Kandahari	3	3	90-97	Rotting
11. Kulu and Kandahari	3	3	88-97·8	Rotting
12. Kulu and Kandahari	4	2	89·5-90·5	Rotting
13. Kulu and Kandahari	4	4	90-95	Rotting
14. Kashmiri	2	2	83·5-95	Partly affected
15. Kashmiri	3	1	89-94	Rotting

Rotting is indicated by a change in colour, generally associated with softening of apples

Dosages of 1, 2, 3 and 4 lb./1,000 c.ft. with exposure of 1, 2, 3 and 4 hours, were used. From the results tabulated in Table II, it will be seen that dosages of 1, 2

and 3 lb./1,000 c.ft. are harmless to Kulu and Kandahari apples when the exposures are 4, 1 and 1 hours respectively.

Mortality of insects. The adults of *T. castaneum* and *O. surinamensis* were picked up at random from the culture. The newly emerged and the older ones as could be distinguished from their respective light and dark colours were avoided. Four to five of such batches containing 50 to 100 of such insects were used per experiment. The per cent mortality tabulated in Table IV is the average of replications.

Mortality count was usually taken 24 to 72 hours after fumigation as death did not occur in all cases immediately after fumigation. With higher dosages, however, death immediately followed fumigation, whereas with lower dosages it took 24 to 72 hours. Death was indicated by stoppage of all movements in the cases of adults for 4 or 5 days together and for larvae the dead ones blackened in colour after death. Controls were also compared, and as in controls insect mortality was negligible, no natural mortality was taken into account. Mortalities of hibernating codling moth larvae are tabulated in Table III and of other insects in Table IV. It may, however, be mentioned that unfortunately the data given in Table III were based on experiments conducted with a limited sample as due to unforeseen circumstances continuous supply of materials could not be obtained.

TABLE III

Mortality of hibernating codling moth larvae

Dosage lb./1,000 c.ft.	Exposure hours	Temperature range °F.	Condition	Mortality per cent
$1\frac{1}{4}$	2	64-67	With silk lining (undisturbed)	20
$1\frac{1}{2}$	2	65-68	With silk lining	100
			Without silk lining (taken out from silk lining)	88
2	2	60-63	With silk lining	100
			Without silk lining	91
2	2	64-68	With silk lining	98
			Without silk lining	82

In one experiment two codling moth larvae were allowed to bore an apple and the apple with the larvae was fumigated with a dosage of 20 mg./L. for $1\frac{1}{2}$ hours. The larvae went in but died when the apple was fumigated.

TABLE IV

Mortality of Tribolium castaneum *and* Oryzaephilus surinamensis *due to fumigation by methyl bromide with different dosages and exposure period*

Serial number	Dosage mg./L.	Exposure hours	Temperature range °F.	Relative humidity per cent	Mortality per cent			
					T. castaneum		*O. surinamensis*	
					Adult	Larva	Adult	Larva
1	15·0	½	86-91	65-80	..	..	32	..
2	16·0	½	86-90	55-70	..	..	11	..
3	15·4	1	92-95	70-90	37	..	95	..
4	15·8	1	86-90	90-100	1	..	..	..
5	16·2	1	88-91	80-100	4	..	94	..
6	16·7	1	92-94	65-85	8	..	94	..
7	16·3	1½	89-94	90-96	54	..	100	100
8	14·9	1½	90-97	60	62	..	100	100
9	16·0	1½	86-93	90-100	49	..	..	..
10	16·6	1½	90-92	84-100	65	..	..	..
11	17·7	1½	90-92	55	34	..	100	..
12	18·4	2	87-94	50	100	..	100	100
13	20·1	1½	92-93	80-100	100	88	100	100
14	23·0	1½	75-81	61-82	69	..	82	..
15	22·8	1	87-92	45	5	..	98	100
16	24·6	1	88-91	80-100	98	..	100	..
17	23·0	2	75-76	65-80	97	..	100	..
18	21·0	2	62-68	85-100	30	..	86	..
19	24·3	2	82-87	80-100	100	..	100	100
20	23·4	2	93-95	90-100	100	..	..	..
21	29·0	1	93-94	63	100	100	100	100
22	31·0	2	64-68	85-100	97	..	100	..

From an inspection of Table IV, it appears that a dosage of 1lb./1,000 c.ft. (16 mg./L.) for 1½ hours or 1½ lb./1,000 c.ft. (24 mg./L.) for 1 hour is lethal to *O. surinamensis* (adults and larvae), whereas a higher dosage and a greater exposure are required for *T. castaneum* (adult), the lethal dosage being 1½ lb./1,000 c.ft. for 2 hours at a temperature range of 85 to 95°F.

It was further observed that ordinarily a dosage of 1½ lb./1,000 c.ft. for 2 hours at 75 to 80°F. does not produce any visible effect on the fruits, but if nuts like shelled almond, walnut or cashew are already infested with *T. castaneum*, the fumigated stuff assumes a pink colour specially at portions from where the outer coverings have been removed.

Discussion

The apparatus described here is a suitable one to study the toxicity of methyl bromide to insects in empty space as well as in presence of grain or other materials, with the advantag s of checking the concentration of fumigant inside the chamber occasionally.

From the experimental results thus obtained it appears that the two varieties of apples tested can stand a constant dosage upto 3 lb./1,000 c.ft. for 1 hour. The dosage in empty space differs to a great extent from the dosage when the chamber is loaded with commodities, as while the sorption tends to decrease the concentration, the occupation of space by commodities increases it. From the results obtained by Dudley *et al* [1940] it is fairly clear that the sorption is negligible in case of apples. In that case the loading of the chamber with apples may by decreasing the free space inside cause the concentration rise much higher than the tolerance limit unless great care is taken to assess the dosage of the fumigant with respect to the free space.

From the second set of experiments it is seen that *T. castaneum* adults are more resistant to methyl bromide than *O. surinamensis* and methyl bromide is fairly toxic to both. From the reports of Dudley *et al* [1940] the sorption of methyl bromide by nuts appear to be fairly large, in which case the maintenance of lethal concentration requires detailed study along with the materials concerned.

Summary

A fumigation chamber for methyl bromide fumigation has been described.

The preliminary observations reported herein led to the following tentative indications :

(1) A dosage of 3 lb./1,000 c.ft. of space of methyl bromide for 1 hour at 80 to 100°F. is harmless to two varieties of apples e.g. Kulu and Kandahari (so far as visible injury is concerned).

(2) A dosage of 1 lb./1,000 c.ft. of methyl bromide for $1\frac{1}{2}$ hours or $1\frac{1}{2}$ lb./1,000 c.ft. for 1 hour at 80 to 90°F. is lethal to *Oryzaephilus surinamensis* in its larval and imago stages. *Tribolium castaneum* adults and larvae require a higher dosage and a higher exposure, viz. $1\frac{1}{2}$ lb./1,000 c.ft. of methyl bromide for 2 hours. At lower temperature a higher dosage or a longer exposure is required for their complete kill.

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REFERENCES

Chapman, P. J., (1940). *J. Econ. Ent.*, **33** (5), 817

Dudley, H. C., Miller, J. W., Neal, P. A. and Sayers, R. R., (1940). *U. S. Publ. Health Rept.*, **55** (49), 2251-2282

Issac, W. E., (1944). *Farming in South Africa*, **19** (224), 703-710

Lewis, S. E., (1945). *J. Soc. Chem. Ind.*, **64** (3), 57-61

Mackie, D. B., (1938). *J. Econ. Ent.*, **31**, 70-79

Mackie, D. B. and Carter, W. B., (1939). *Bull. Dept. Agric. Calif.*, **28** (6), 378-386, 1940 *Rev. Appl. Ent.*, **28** (4) A, 186-187

Monro, H. A. U. and Delisle, R., (1945). *Sci. Agric.*, **25**, 794-816

Phillips, W. R., Monro, H. A. U. and Allen, C. E., (1938). *Sci. Agric.*, **19**, 17-20

Phillips, W. R. and Monro, H. A. U., (1939). *J. Econ. Ent.*, **32** (2), 344-45

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